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TERRORISM OUTSOURCED: THE FARC'S CRIMINAL ALLIANCES

by

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December 2014

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Colombia has been in the midst of peace talks with the Revolutionary Armed Forces of Colombia (FARC) since 2011. This process could follow the trend in attempted resolutions of other internal armed conflicts in Latin American countries such as Guatemala, El Salvador, and Nicaragua. These Central-American countries experienced peaks in violence and the emergence of splinter criminal groups after their respective governments reached agreements with the guerrillas. A similar situation can occur in Colombia, particularly if a hardline subgroup from the FARC does not want to commit to peace agreements. This research focuses on the set of terrorists that will continue their activities by forming alliances with criminal groups. In order to understand this potential risk, this research uses social network analysis techniques on three recent cases of terrorist-criminal association, in which the FARC has subcontracted criminal organizations to conduct operations on its behalf. The analysis sheds light on the social structure of these networks, their actors' centrality, the organizations' centralization, and their transformation over time. The results of this analysis contribute to identify some important considerations to strengthen the state and the nation's security.

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ABSTRACT

Colombia has been in the midst of peace talks with the Revolutionary Armed Forces of Colombia (FARC) since 2011. This process could follow the trend in attempted resolutions of other internal armed conflicts in Latin American countries such as Guatemala, El Salvador, and Nicaragua. These Central-American countries experienced peaks in violence and the emergence of splinter criminal groups after their respective governments reached agreements with the guerrillas. A similar situation can occur in Colombia, particularly if a hardline subgroup from the FARC does not want to commit to peace agreements. This research focuses on the set of terrorists that will continue their activities by forming alliances with criminal groups. In order to understand this potential risk, this research uses social network analysis techniques on three recent cases of terrorist-criminal association, in which the FARC has subcontracted criminal organizations to conduct operations on its behalf. The analysis sheds light on the social structure of these networks, their actors' centrality, the organizations' centralization, and their transformation over time. The results of this analysis contribute to identify some important considerations to strengthen the state and the nation's security.

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LIST OF ACRONYMS AND ABBREVIATIONS

AKA	also known as
AUC	United Self-Defense of Colombia (Autodefensas Unidas de Colombia in Spanish)
ARD	average of reciprocal distance
BACRIM	emergent criminal gangs (bandas criminales emergentes in Spanish)
CMTF	Mobile Column Teofilo Forero
CUSUM	cumulative sum
ETA	Euskadi Ta Askatasuna (Basque Homeland and Freedom)
FARC	Revolutionary Armed Forces of Colombia (Fuerzas Armadas Revolucionarias de Colombia in Spanish)
IBD	Inter-American Development Bank
IED	improvised explosive device
NPS	Naval Postgraduate School
ORA	organizational risk analyzer
SNA	social network analysis
SNCD	social network change detection
SPC	statistical process control

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I.   INTRODUCTION

A.   BACKGROUND

Peace processes are the most effective way to end internal armed conflicts.[1] They seek to address the social, economic, and political causes that give birth to violence. Nevertheless, recent Latin American history reveals moments of tension during the consolidation of signed agreements between the parties. These moments manifest themselves in acts of violence, such as selective homicides and terrorism. In other cases, they have generated splinter groups that seek to conduct criminal or terrorist activities independently.

An example of diminishing security was apparent at the end of the Nicaragua's internal armed conflict in 1990. Notwithstanding efforts to reset the country economically and to create mechanisms of social equality, some sectors that did not benefit by the agreed measures experienced significant breakouts of violence. It is estimated that between 1990 and 1996 "armed bands roaming the countryside were responsible for an estimated 1,000 deaths and 600 kidnappings."[2] In El Salvador violence was similar and complex. Impoverished rural areas were the most affected, perhaps influenced by the unemployment rate that nearly reached 80 percent of population in the early 1990s.[3] A study published by the Inter-American Development Bank showed that El Salvador had the highest per capita homicide rate in the world in the mid-1990s.[4] Similarly, Guatemala faced extreme conditions of violence at the end of its peace process.

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[1] Daniel Matul and Alonso Ramírez, "El Proceso De Paz En Centroamérica. Agendas Pendientes y Nuevos Focos De Conflictividad: Los Casos De Guatemala y Nicaragua" [Peace process in Central America. Pending agendas and new focuses of conflictivity: The cases of Guatemala and Nicaragua], *Pensamiento Propio*, no. 14 (Enero-Junio, 2009): 101–102.

[2] Roland Paris, *At War's End: Building Peace after Civil Conflict* (New York: Cambridge University Press, 2004), 118.

[3] Ibid., 126

[4] Economist Intelligence Unit, London (GB), *Country Profile Guatemala and El Salvador 1996–97* (1996), 42.

Since 1996, security conditions have deteriorated in rural zones where landlord-ownership problems were not resolved in the peace process framework. Some World Bank observers have informed in their reports that "Guatemala has become a substantially more violent country since the end of the internal armed conflict."[5]

Currently, Colombia is in the midst of peace talks with the Revolutionary Armed Forces of Colombia (FARC). By reaching an agreement to end the conflict, the parties will generate verification mechanisms to comply with their commitments. However, previous Latin-American conflicts show that tensions and violence are frequently part of the outcome in peace agreements. Therefore, one might argue that these events may also happen in Colombia.[6]

A recent example in this country is the demobilization of the United Self-Defense Groups of Colombia (AUC), which were comprised of 40 subgroups between the years 2000 and 2006. Of these, six did not demobilize and most became what are known as emergent criminal gangs (BACRIM).[7] Their formation was caused by "the fusion of several generations and criminal streams, some with and others without ideological reference (counterinsurgency), with different levels of organizational capacity and territorial control."[8] The BACRIM conduct criminal activities related to drug trafficking, extortion, and illegal exploitation of mineral deposits.

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[5] Caroline O. N. Moser and Cathy McIlwaine, *Violence in a Post-Conflict Context: Urban Poor Perceptions from Guatemala* (Washington, DC: World Bank Publications, 2001), 13.

[6] Enzo Nussio and Kimberly Howe, "What if the FARC Demobilizes?" *Stability: International Journal of Security and Development* 1, no. 1 (2012): 58–67.

[7] Observatorio de Procesos de Desarme, Desmovilización y Reintegración, *Estructuras De Autodefensa y Proceso De Paz En Colombia [Self-defense structures and peace process in Colombia]* (Bogota, Colombia: Universidad Nacional de Colombia, 2012).

[8] Daniel M. Rico, "Las Dimensiones Internacionales Del Crimen Organizado En Colombia: Las Bacrim, Sus Rutas y Refugios" [The international dimension of organized crime in Colombia: The Bacrim, their routes and shelters], *La Diáspora Criminal: La Difusión Transnacional* (2013), 33.

B.   RESEARCH CONTEXT

The historical context of internal conflicts seems to culminate with patterns of violence and a transformation of criminal actors. This thesis argues that a hardline sector of the FARC will reject the peace process because they do not trust the government's commitments to respect human rights by security forces, which could ultimately affect their personal security. Many of them also face legal consequences because they committed crimes during their membership in the organization. Moreover, they might find it unappealing to leave behind their criminal activities (drug trafficking, kidnapping, extortion, and other offenses) that have allowed them to enjoy a wealthy lifestyle. These patterns of behavior are seen frequently during demobilization and disengagement processes in Colombia, and are contrary to the process of consolidating peace agreements.[9]

The scope of this thesis focuses on the FARC members who do not want to participate in the peace process and who will not follow procedures of disarmament, demobilization, and reintegration. This area is interesting to analyze from the viewpoint of terrorist-criminal alliance formation. Alliances between terrorists and criminals are processes by which members of certain organizations seek to expand their financial capacity and ability to conduct violence by attracting criminal gangs that can help them pursue their interests. The formation of alliances could focus on the employment of small groups to carry out activities on their behalf, or on the union with various syndicates to strengthen themselves and start a new autonomous criminal or terrorist organization. This cooperation provides a major opportunity to confront the legal and security actions of Colombian authorities.

There are several reasons why groups would want to engage in criminal or terrorist activities. First, territorial control largely determines criminal power, and criminal groups execute illegal actions in the absence of institutions of the

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[9] Marcella Ribetti, "Disengagement and Beyond - A Case Study of Demobilization in Colombia," in *Leaving Terrorism Behind - Individual and Collective Disengagement*, eds. Tore Bjørgo and John Horgan (New York: Routledge, 2009), 152.

state, which allows them to control the region's social, economic, and political powers. Second, financial motivations are the center of attention, evolution, and violence of criminal groups. In the Colombian case, some regions are still affected by the drug trafficking while criminal activities, such as the illegal exploitation of mineral deposits, kidnappings, extortion and homicide, among others, contribute to the financial strength of these groups. Third, state control requires a strategic vision by the criminal organization; it has the objective to co-opt state institutions, and manipulate and seek support from the inhabitants of the affected territory.[10]

C.   RESEARCH QUESTIONS

Consequently, in order to safeguard Colombia's future, it is necessary to assess the state's capacity to face a new generation of criminals. This thesis seeks to answer the following questions: What are the most relevant characteristics in the formation of criminal alliances by the FARC? What impact do they have on public security? How can the Colombian authorities face this potential problem in the future and what can be done to prevent a spiral of violence? To answer these questions this thesis explores three recent cases where the FARC formed alliances with criminal organizations. By analyzing these cases, it seeks to identify the most prominent features of those alliances, which, in turn, will help Colombian authorities implement strategies against criminal groups in the post-conflict framework.

D.   RESEARCH SCOPE

This thesis seeks to identify the most relevant characteristics during the formation of criminal alliances under the modality of subcontracting. The main objective is to analyze the settings of terrorist networks in charge of the FARC and the behavior of their members as their networks evolved over time.

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[10] Luis Jorge Garay et al., *La Captura y Reconfiguración Cooptada Del Estado En Colombia* [The capture and co-opted reconfiguration of the state in Colombia] (Bogota, Colombia: Transparencia por Colombia, 2008), 108.

The three cases of FARC-criminal alliances analyzed in this research all resulted in homicide and terrorism, and all had a significant impact on Colombian society because of the social and political importance of the victims. The first case is the homicide of Archbishop Isaías Duarte in Cali, Colombia, on March 16, 2002. The context of this event was complex because the government ended a peace process with the FARC on February 2002. The dialogue between the government and the FARC began in 1999 during Andrés Pastrana's presidency, which concluded in August of that year.

The second is the terrorist attack against the El Nogal club in Bogotá, Colombia, which occurred on February 7, 2003, and left 36 dead and 164 injured. The El Nogal club is well-known because its members are largely politicians, journalists, and businessmen of high society. This action was considered one of the tipping points that allowed the government to strengthen security in Colombia through the Democratic Security Policy under the presidency of Alvaro Uribe.

The third is the terrorist attack against former minister of the interior Fernando Londoño-Hoyos in Bogotá, Colombia. The terrorists activated an improvised explosive device (IED), known as *lapa*, in Londoño's vehicle when it was traveling through a commercial area. The event occurred on May 16, 2012, and it left two dead and 51 injured. That day, Congress was deciding the future of a law project that gave legal life to any peace process in Colombia with insurgents.

The major feature of these three cases was the FARC's decision to subcontract their implementation with small criminal gangs. The FARC subgroups linked to these events have been labeled as the most violent in the nation. Nevertheless, key elements of these networks are less clear, including personal relationships formed during the planning and execution of the terrorist actions along with evolution of these ties once the gangs accomplished the task.

The method employed in this research is social network analysis (SNA). With greater detail in Chapter II, this investigation explains the procedures and

analysis performed in order to identify the characteristics of these criminal alliances. SNA is a collection of theories and techniques that have been fostered by scientific fields such as anthropology and from theories such as graph theory. Sociologists use SNA to understand the relationships between actors, and as a tool, to identify trends in actor behavior. The next section, the literature review, will expand on SNA and delve deeper into important aspects of criminal and terrorist alliances.

E.   LITERATURE REVIEW

This section seeks to deepen knowledge related to two aspects of interest related to this research. It first focuses on cooperation between criminal organizations. It then presents the importance of SNA when employed to identify characteristics of criminal behavior.

1.   Cooperation between Criminal Organizations

An abundance of literature exists with regards to the causes and effects of cooperation between criminal organizations. The German sociologist Georg Simmel and later Bonnie Erickson, examined the nature of secret societies and their features of reciprocal trust and the protection of common interests.[11] Erickson examined societies under risk, that is, groups whose members are in danger of imprisonment, injury, or death. She argued that for these organizations, "the crucial motive is a desire to maximize security."[12] In the case of the FARC's alliances with criminal groups, one could argue that the FARC is seeking to maximize its security by allowing the criminal groups to take most of the risks.

Several studies have focused on the methods by which organizations form associations and on the transformation of the groups after an alliance is formed.

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[11] Georg Simmel, *Conflict and the Web of Group Affiliations* (New York: The Free Press, 1955).

[12] Bonnie H. Erickson, "Secret Societies and Social Structure," *Social Forces* 60, no. 1 (September 1981): 188–210.

For instance, Julie Ayling draws on evolutionary theory in her analysis of how gangs change[13] and Bill McCarthy, Jim Hagan, and Lawrence Cohen use game theory to show how criminals solve social dilemmas. An important focus of this latter study is the willingness of one group to trust in another to carry out cooperative endeavors. These alliances reveal margins of uncertainty that lead associates to face adversity. The authors suggest that "adversity increases people's sense of desperation and networks provide access to potential cooperators, criminal capital, and information on people's reputation for trustworthiness."[14] As a result, network actors may be willing to undertake risky actions. This suggests that criminal groups analyzed in this thesis may have trusted the FARC far too much and consequently underestimated the risks they were taking.

The FARC sought associations with criminal gangs they knew well and who were experts in much needed skills. It required that the criminal gangs were able to fulfill the operations for which they were subcontracted. This commitment to accomplish terrorist operations can be associated with what Paolo Campana and Federico Varese propose regarding the establishment of credible commitments among two or more criminal parties. They found that "the likelihood of cooperation is higher among members who are related," as well as "among members who have shared information about violent acts."[15]

Finally, social capital theory focuses on the interaction of actors who seek to maintain or gain different resources, such as wealth, power, and reputation.[16] An important assumption of this theory is that the position of an actor in a

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[13] Julie Ayling, "Gang Change and Evolutionary Theory," *Crime, Law & Social Change* 56, no. 1 (August 2011): 1–26.

[14] Bill McCarthy, John Hagan, and Lawrence E. Cohen, "Uncertainty, Cooperation, and Crime: Understanding the Decision to Co-Offend," *Social Forces* 77, no. 1 (September 1998): 174.

[15] Paolo Campana and Federico Varese, "Cooperation in Criminal Organizations: Kinship and Violence as Credible Commitments," *Rationality and Society* 25, no. 3 (2013): 271.

[16] Nan Lin, *Social Capital: A Theory of Social Structure and Action* (New York: Cambridge University Press, 2001).

network gives him access to resources that are embedded in social relations. Social capital is often seen as something positive, but terrorist and criminal organizations can draw on it as well. As we will see in the case of the FARC, when outsourcing its terrorist operations, it sought to build ties with criminal organizations that could most efficiently mobilize the necessary resources for carrying out the desired attacks.

The causes and effects of cooperation between criminal organizations are diverse and many variables could influence, in different ways, the formation of ties between individuals and organizations. Each organization's context provides a myriad of features that need individual analysis to understand its structure and behavior. For these reasons, one can assert that the use of SNA is the most appropriate methodology to understand the context in which the relationships between individuals are established and the evolution of these networks over time.

2.   Importance of Social Network Analysis

Social network analysis "is a collection of theories and methods that assume that behavior of actors is profoundly affected by their ties to others and the networks in which they are embedded."[17] It can be used to identify key aspects of a criminal organization, such as its overall topography, its central actors, and so on. SNA methods have been used in other studies to examine criminal networks and their behavior in various contexts; therefore, its use in this context should return insights for developing strategic options that can be made to Colombian security agencies.[18]

Criminal networks have complex structures and behavioral features. Many of Colombia's criminal networks have their roots in the Medellín Cartel, which

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[17] Sean F. Everton, *Disrupting Dark Networks*, Vol. 34 (New York: Cambridge University Press, 2012), 5.

[18] Andrew Mark Fox, et al., "Examining Gang Social Network Structure and Criminal Behavior," (Ph.D. diss., Arizona State University, 2013).

operated in Colombia during the 1970s and 1980s. An analysis by Rebekah Dietz suggests that the network was dense at its core and centralized around a few members that made decisions for the whole group.[19] In contrast, the network that took over the cocaine trade after the demise of the Medellin Cartel appears to have been less centralized and often subcontracted various activities out to other organizations in Mexico, Venezuela, and Ecuador. This allowed them to be resilient and imperceptible to judicial authorities.[20]

The evolution of criminal organizations can be understood from a network analysis perspective. H. Brinton Milward and Jörg Raab argue that criminal networks are "dynamic, not static."[21] Members understand that for their survival, they must adapt to a given context, which in many cases means they must rely on others through the formation of alliances.

F.   THESIS OUTLINE

This thesis contains six chapters. Chapter I provides the background related to the potential consequences that may arise at the end of internal armed conflicts. It also introduces the purpose and context of this research along with a literature review of the topics discussed in this thesis. Chapter II offers a detailed discussion social network analysis methods and metrics that this thesis uses. Chapters III, IV, and V analyze, respectively, the three terrorist operations discussed earlier that the FARC subcontracted out to criminal organizations. Finally, Chapter VI offers conclusions, a summary of the research, and implications for Colombian law enforcement authorities.

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[19] Rebekah K. Dietz, "Illicit Networks Targeting the Nexus between Terrorists, Proliferators, and Narcotraffickers" (master's thesis, Naval Postgraduate School), 84–86.

[20] United Nations Office on Drugs and Crime, "Results of a Pilot Survey of Forty Selected Organized Criminal Groups in Sixteen Countries," United Nations, https://www.unodc.org/pdf/crime/publications/Pilot_survey.pdf.

[21] H. Brinton Millward and Jörg Raab, "Dark Networks: The Structure, Operation, and Performance of International Drug, Terror, and Arms Trafficking Networks," *International Conference on the Empirical Study of Governance, Management, and Performance* 6 (October 2002), 2004.

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II. METHODOLOGY AND DATA

As noted in the introductory chapter, this thesis will draw on SNA as its methodology. This chapter proceeds as follows. First, it discusses the reasons for choosing the three specific cases when the FARC subcontracted operations to criminal groups. Next, it details how the data analyzed in this paper were collected and processed. Finally, it discusses the SNA metrics used to analyze the three networks.

A.   TERRORISM AND HOMICIDE CASES

Several reasons exist for examining the three cases studies mentioned in the previous chapter. The most relevant reason is that the FARC subcontracted those events of terrorism and homicide. The phenomenon of criminal subcontracting is important because the FARC typically plans and executes its own operations. That said, there are at least three reasons why the FARC would subcontract some of its operations out to criminal groups. First, outsourcing operations lowers the amount of risk the FARC takes on. For practical and efficacious reasons, prosecutors might prefer to locate and bring the direct perpetrators of the events to justice based on the fact that they are more likely than the planners to leave behind incriminating evidence. The second reason is that it increases the physical security of the FARC members. Remote commanding a terrorist event might contribute to preserving their capabilities and knowledge to deploy further operations. A third reason is the reduction of costs. Members of the terrorist organization could divert money for their interests, but with a subcontracted group, the terrorists are bound to pay what they have agreed.

These reasons are even more compelling when one considers crime dynamics in Colombia. The FARC's violence, along with that of other criminal groups, has engulfed the country, though most of the time the groups operate

autonomously. Table 1 summarizes criminal activity from 2003 and 2013. The Ministry of Defense of Colombia collected the data.

Table 1.   Summary of crimes and their modalities between the years 2003 and 2013.

Crimes	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Total
Homicide	23,523	20,210	18,111	17,479	17,198	16,140	15,817	15,459	16,127	16,440	15,419	191,923
Injuries	40,042	32,535	30,415	46,529	47,957	66,315	55,130	53,181	62,194	82,183	82,940	599,421
Kidnappings	2,123	1,440	801	690	523	437	213	282	305	305	299	7,418
Terrorism	1,258	724	612	646	387	486	489	472	571	894	890	7,429
Assult on municipalities	9	2	4	2	0	0	2	5	0	2	0	26
Aircraft attacked	23	3	7	7	3	6	2	4	7	3	6	71
Facilities attacked	38	17	14	7	3	0	6	9	20	23	30	167
Firepower harassment	223	140	101	65	30	19	88	59	76	80	74	955
Ambushes	60	29	31	15	9	15	29	32	24	32	18	294
Armed contact	84	26	39	21	11	8	16	11	13	10	4	243
Raid to municipalities	0	0	0	0	0	1	0	0	3	1	0	5
Illegal check points	234	102	71	49	19	3	18	11	9	16	23	555
Armed forces KIA	597	590	717	594	457	373	468	487	484	377	361	5,505
Armed forces wounded	1,853	1,949	1,635	1,699	1,801	1,692	1,852	2,031	2,265	2,468	2,609	21,854

Criminal behavior provides a perspective on the myriad of criminal activities pursued during the last decade. Nevertheless, all of the offenses are not attributable to the FARC even though it was extensively involved in every type of crime committed in the country. Its active participation in criminal events is the tipping point that leads this research to emphasize that criminal subcontracting by the FARC is relevant as a subject of analysis, especially in light of the current peace negotiations in Colombia between the FARC and the Colombian government.

Subcontracting operations to criminal organizations will also provide benefits to the criminal subcontractor. First, the subcontracted actor seeks a new structural position both during and after the transaction. In the case of a criminal subcontractor, the arrangement provides recognition and respect among its peers in the criminal world. Second, this kind of relationship guarantees to the contracting party flexibility to execute tasks, access to new technology, and gain

"service improvement."[22] In the framework of criminal alliances, outsourcing contributes to consolidating the FARC's security because most of the risk lies with the subcontracted criminal organizations. Third, once the groups fulfill their assigned tasks, the participants will often remain linked to each other.[23] That, at least, is the desire of the subcontractors; they are eager to form sustaining relationships with the FARC. This eagerness, however, is not always reciprocated by the FARC.

In order to highlight the importance of these three case studies, this research draws from experts from the Colombian National Police. Analysts of the law enforcement agency agree that these are significant cases of criminal subcontracting by the FARC. Likewise, with the help of the NPS Defense Analysis Department faculty, it was possible to identify the relevance of the subject and possibly its importance for decision making in Colombia.

B.   COLLECTION AND INFORMATION PROCESSING

Three data sources were used for this thesis's investigation. The first were open sources (i.e., free access to public): namely, the digital versions of Colombia's largest media outlet *El Tiempo* (founded in 1911),[24] *El Espectador* (founded in 1887),[25] *El Colombiano* (founded in 1912),[26] *El País* (founded in 1950),[27] and *Semana* (founded in 1982).[28]

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[22] The terrorist organization expected its goals to be fulfilled by reducing the costs of their investment.

[23] Royston Morgan, "The Context and Narrative of Outsourcing," in *The Human Side of Outsourcing: Psychological Theory and Management Practice*, ed. Stephanie J. Morgan (Malden, MA: John Wiley & Sons, 2009), 106–119.

[24] *El Tiempo*, "Noticias De Colombia" [News from Colombia], http://www.eltiempo.com/.

[25] *El Espectador*, "Noticias De Colombia" [News from Colombia], http://www.elespectador.com/noticias.

[26] *El Colombiano*, "Noticias De Colombia" [News from Colombia], http://www.elcolombiano.com/portada.asp.

[27] *El Pais*, "Noticias De Colombia" [News from Colombia], http://www.elpais.com.co/.

[28] *Semana*, "Noticias De Colombia" [News from Colombia], http://www.semana.com/.

The second were public judicial reports, which were located using the judicial processes search service of the Colombian judicial branch. Its webpage allows data scanning on individuals prosecuted in the case studies.[29] Likewise, Internet queries returned judicial reports with data about the members of the criminal organizations and how they planned and executed every event.

The third type of source is primary source police information. Through formal requests to the Colombian police intelligence service, it was possible to obtain depersonalized information about the individuals and the groups involved in the planning and execution of the events. Although this information is interesting and its structure complies with NPS guidelines about human research subjects, it is primarily used as a lens to reduce the uncertainty of the information gathered in this research.

Once the collection of data was complete, the task of information processing began. Palantir Technologies, which allows users to organize and visualize relationships between people, locations, and events, was used to structure the data.[30] Structured data is essential to build a timeline of every network and to define the boundary of each group with regard to its associates. This data organization determined the evolution, consolidation, and termination of each network.

The three networks have characteristics akin to each other regarding their data structure. These organizations are one-mode networks with undirected ties. The relationships between nodes are at the individual level and they represent operational ties. For the purposes of this thesis, operational relationships are defined as the ties between two actors who belong to the same organization, who have participated in the same events, or who have an intimate relation that affects in any way the behavior of the overall network. The Isaías Duarte overall

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29 Rama Judicial de Colombia, "Consulta De Procesos" [Processes' consultation], http://procesos.ramajudicial.gov.co/consultaprocesos/.

30 Palantir Technologies, *Nps Osint*, 2014 ed., version 3.8.2.8.603030, 2004. More information about this tool is available at https://www.palantir.com/

network has 21 actors and 146 ties, the El Nogal network has 27 actors and 156 ties, and the Fernando Londoño network has 25 actors and 146 ties.

The networks also have similar characteristics in their formation of ties over time. This thesis defines the existence of relationships when the actors have conducted operations together and when they coincide in time and space in the same organization. The length of these relationships remains until an actor is dead; similarly, a relationship ends when the actor is arrested and/or remains in jail.

C. DATA EXPORT TO SNA TOOLS

From Palantir, the data were exported to other analytical software tools, including UCINET.[31] This SNA program allows analysts to check every adjacency matrix and clean them in order to verify the accuracy of data regarding nodes and their visualization in the sociograms. The matrices were transformed into edgelists, which were edited to include temporal data (i.e., time stamps) so that the time period in which each actor was present in the network, as well as the length of his relationships with other actors, is captured. This permitted the creation of networks over time using the SNA software package Pajek.[32]

The information was then exported to the SNA tool, Organizational Risk Analyzer (ORA),[33] which includes the longitudinal analysis tools needed for this research. It is important to note that in order to execute these procedures, the research follows the guidelines suggested in the book *Disrupting Dark Networks*.[34] Likewise, the guidelines and other concepts were researched in the

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[31] Stephen P. Borgatti, Martin G. Everett, and L. C. Freeman, *UCINET 6 for Windows*, Version 6.491 (Harvard, MA: Analytic Technologies, 2002).

[32] Andrej Mrvar and Vladimir Batagelj, *Pajek*, Version 64 3.08, 1996.

[33] Kathleen M. Carley, *Organizational Risk Analyzer ORA*, Version 2.3.6 (Pittsburgh, PA: Carnegie Mellon University, 2001–2011).

[34] Everton, *Disrupting Dark Networks*, 451.

books: *Exploratory Social Network Analysis with Pajek*[35] and *Analyzing Social Networks.*[36]

D. ANALYSIS OF DARK NETWORKS–EXPLORATORY, DESCRIPTIVE, AND LONGITUDINAL

1. Overall Network Topography

The first step an analyst should follow is the exploration of the network's topography. Following Sean F. Everton, it is possible to examine two distinct, yet somewhat related, topographical dimensions,[37] which are related to a network's level of effectiveness or performance. The first set is the cosmopolitan-provincial dimension. Density is one of the measures that characterize this dimension. It measures the proportion of ties in the network. Unfortunately, this measure is inversely related to network size because as additional nodes join a network, the number of possible ties grows exponentially. An alternative measure to density is average degree, which equals the mean number of ties of each actor in a network and is "a better measure of overall cohesion than density because it does not depend on network size."[38]

Furthermore, networks may have higher or lower levels of clustering, which may indicate a greater or lesser presence of strong or weak ties. The latter reflects upon Mark Granovetter's study on the strength of weak ties.[39] Weak ties, according to Granovetter, "are more likely to form crucial bridges that tie together densely knit clusters of people."[40] Strong ties, on the other hand, have important

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[35] Wouter De Nooy, Andrej Mrvar, and Vladimir Batagelj, *Exploratory Social Network Analysis with Pajek*, Vol. 27 (New York: Cambridge University Press, 2005), 334.

[36] Stephen P. Borgatti, Martin G. Everett, and Jeffrey C. Johnson, *Analyzing Social Networks* (Thousand Oaks, CA: SAGE Publications, 2013).

[37] Sean F. Everton, "Network Topography, Key Players, and Terrorist Networks," *Connections* 32, no. 1 (June 2012): 12–19.

[38] De Nooy, Mrvar and Batagelj, *Exploratory Social Network Analysis with Pajek*, 64.

[39] Mark S. Granovetter, "The Strength of Weak Ties," *American Journal of Sociology* 78, no. 6 (May 1973): 1360–1380.

[40] Everton, "Network Topography, Key Players, and Terrorist Networks," 13

features to the organization. Studies about human behavior argue that strong ties are those relationships that give support to people at moments of difficulty.[41] However, some studies explain the benefits of groups that combine strong and weak ties.[42]

The clustering coefficient is one measure that can be used to estimate the level of clustering in a network. It captures "the extent to which a network [has] areas of high and low density."[43] The idea behind the clustering coefficient is that "human social systems are very clumpy (thanks to factors such as homophily, geographical concentration, a tendency to develop relations with one's relations' relations)."[44] Likewise, human systems are very compact in the sense of having short paths linking everyone to everyone else.[45] To obtain this measure one calculates the density of each ego network. It only uses ties between ego alters and calculates the average of these scores.[46] When Watts and Strogatz developed this algorithm, some SNA software incorporated its automation but calculated results only for actors with two or more alters, and when the tools determine the average, they divide it by the number of actors with the clustering coefficient. This situation could lead to mistakes when dealing with sparse networks; for that reason, ORA generates an alternative measure in which the average is calculated by dividing the average by the total number of actors. For this investigation, both calculations are used. With the clustering coefficient, it is

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41 R. Stark, *Sociology*, 10th ed. (Belmont, CA: Wadsworth Publishing Company, 2007), 37, quoted in Everton, "Network Topography, Key Players, and Terrorist Networks," 14.

42 References to this perspective can be found in Brian Uzzi, "The Sources and Consequences of Embeddedness for the Economic Performance of Organizations: The Network Effect," *American Sociological Review* 61, no. 4 (August 1996): 675–677; Brian Uzzi and Jarrett Spiro, "Collaboration and Creativity: The Small World Problem," *American Journal of Sociology* 111, no. 2 (September 2005): 464.

43 Duncan J. Watts and Steven H. Strogatz, "Collective Dynamics of 'Small-World' Networks," *Nature* 393, no. 6684 (1998): 440–442.

44 Borgatti et al., *Analyzing Social Networks*, 156.

45 Stanley Milgram, "The Small World Problem," *Psychology Today* 2, no. 1 (1967), 60–67.

46 Everton, *Disrupting Dark Networks*, 149.

possible to calculate what is called the small-world quotient. This quotient tells "how connected and cohesive the relations in the global network are, indicating how productive or unproductive the distribution of creative material and relationships are across the global network."[47] To calculate the small-world quotient, one divides the clustering coefficient by the density of the network.[48]

The second topographical dimension, or the hierarchical-heterarchical dimension, is related to the levels of centralization in a network. One set of measures, centralization, "uses the variation in actor centrality within the network to measure the level of centralization."[49] This research employs the following measures of centrality: degree, betweenness, closeness, and eigenvector. An alternative centralization measure is standard deviation.[50] It (SD)—expressed in Equation 2.1—is the square root of the variance, which is "the sum of the squared differences between each actor's centrality score $\left(C\left(n_i \right) \right)$ and the average centrality score $\left(\overline{C} \right)$."[51]

$$SD = \sqrt{\frac{\left\lceil \sum_{i=1}^{n} \left(C\left(n_i \right) - \overline{C}^z \right\rceil \right)}{n}} \qquad (2.1)$$

These results seek to highlight the overall performance of the network. Its objective is to shed light on the decision-making process concentrated in some actors of the organization.

Table 2 summarizes the topographical criteria. These parameters allow an analyst to label networks in their topographical dimensions and use them for crafting strategies and tactics against criminal or terrorist organizations.

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[47] Uzzi and Spiro, "Collaboration and Creativity: The Small World Problem," 464.

[48] Everton, *Disrupting Dark Networks*, 149.

[49] Ibid., 152.

[50] Lawrence C. Hamilton, *Data Analysis for Social Scientists: A First Course in Applied Statistics* (Belmont, MA: Duxbury Press, 1995), 72–73.

[51] Everton, *Disrupting Dark Networks*, 153.

Table 2.　Topographical dimensions of networks.

DIMENSION	DENSITY	CLUSTERING	TIES	CENTRALIZATION	VARIANCE
Cosmopolitan	sparse	low levels	+ weak ties		
Provincial	dense	high levels	+ strong ties		
Hierarchical				centralized	high levels
Heterarchical				decentralized	low levels

2.　　Measures of Actor Centrality

Centrality measures are perhaps the most intuitive of all SNA metrics. According to Borgatti, Everett, and Johnson, "centrality is a property of a node's position in a network;"[52] it indicates a node's potential power in terms of opportunities, influence, and the control of the flow of resources throughout a network.

The most common centrality measure is degree centrality, which is the count of an actor's ties. It captures "an actor's level of involvement or activity in the network."[53] The value of this centrality measure is its insight about which actors are more active in the consolidation of ties through different times and levels of social relations (e.g., operational ties, friendship ties or business ties).

Closely related to degree centrality is eigenvector centrality. It equals the sum of an actor's connections to other actors, weighted by their degree centrality.[54] This algorithm seeks to establish the relationship of actors with others who are very active and perhaps influential in an organization. During the analysis of eigenvector centrality one might consider significant differences in the scale between a node with the highest value and the following node. According to Borgatti et al., the value of the first should be "two or three times as large as

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[52]　Borgatti, Everett, and Johnson, "Analyzing Social Networks," 164.

[53]　Christina Prell, *Social Network Analysis: History, Theory and Methodology* (Thousand Oaks, CA: SAGE, 2012), 97.

[54]　Phillip Bonacich, "Power and Centrality: A Family of Measures," *American Journal of Sociology* 92, no. 5 (March 1987), 1172.

the second largest. Otherwise, it could be argued that you really need more than one eigenvector to represent the position of the node in the network."[55]

Another common measure is betweenness centrality. It "is based upon the frequency with which a point falls between pairs of other points on the geodesic paths connecting them."[56] An important matter with this measure is that a given actor might choose another path even if it is longer and less efficient;[57] therefore, actors have limited potential for control over whatever resource that passes through them.

Finally, closeness centrality provides a different approach to resource control in an organization. According to Alex Bavelas, and later to Harold J. Leavitt, a central node is one that does not depend on others to serve as intermediaries. The closest node to other nodes has easier and faster access to resources that flow through the network.[58] An alternative closeness measure is the average of reciprocal distance (ARD). Unlike the standard measure, it is not sensitive to disconnected networks in which it is necessary to remove isolates to calculate a reliable score.[59] Fortunately, all three networks examined here are connected, thus allowing the application of the standard closeness measure.

Centrality measures provide analysts a vision of the actors that are potentially more active and influential in the network. For the analysis of the three case studies in this research, these measures shed light on the behavior of actors over time.

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[55] Borgatti, Everett, and Johnson, "Analyzing Social Networks," 168–169.

[56] Linton C. Freeman, "Centrality in Social Networks Conceptual Clarification," *Social Networks* 1, no. 3 (1979): 221.

[57] Linton C. Freeman, Stephen P. Borgatti, and Douglas R. White, "Centrality in Valued Graphs: A Measure of Betweenness Based on Network Flow," *Social Networks* 13, no. 2 (1991): 141–154.

[58] Alex Bavelas, "Communication Patterns in Task-Oriented Groups," *Journal of the Acoustical Society of America* 22, no. 6 (1950): 725–730; Harold J. Leavitt, "Some Effects of Certain Communication Patterns on Group Performance," *The Journal of Abnormal and Social Psychology* 46, no. 1 (1951): 38.

[59] Everton, *Disrupting Dark Networks*, 217.

3. Longitudinal Analysis

Networks are subject to different contexts that make them dynamic. Ian McCulloh argues that "in a social network context, the individual goals and motives of a person, among other factors may drive the network to evolve."[60] This assumption indicates that there are endogenous and exogenous factors that contribute to change in organizations and relationships among their members.

The possibility to identify changes quickly is an advantage for decision-making processes. In this regard, the methodological scope of this research is social network change detection (SNCD), which provides a visual understanding of statistically significant changes in network structures and guides analysts to identify potential causes of such changes. McCulloh and Kathleen M. Carley assume that this is possible through the use of a statistical process control (SPC) like those employed by quality engineers. Thus, monitoring can be exerted on any topographical and centrality measure. Analysts can use this tool in ORA.[61]

Here we use the cumulative sum (CUSUM) control chart for monitoring and detecting changes in the network.[62] Accurate detection is an advantage because statistical monitoring determines the scope of the investigation by narrowing the timeframe to the moment before drastic changes occurred. CUSUM employs a reference value and control limit scores which seem to be set arbitrarily and with accordance to industry standards. These values identify false alarms of significant changes of the network.[63]

SNCD requires the configuration of timeframes for an accurate analysis. This research defines different time periods to assess significant changes in the

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[60] Ian McCulloh, "Detecting Changes in a Dynamic Social Network" (Ph.D. diss., Carnegie Mellon University, 2009).

[61] Ian A. McCulloh and Kathleen M. Carley, *Social Network Change Detection* (Pittsburgh, PA: Center for the Computational Analysis of Social and Organizational Systems, 2008).

[62] E. S. Page, "Cumulative Sum Charts," *Technometrics* 3, no. 1 (1961): 1–9.

[63] Ian A. McCulloh, "Generalized Cumulative Sum Control Charts" (master's thesis, Florida State University, 2004), 56.

network. Nevertheless, every particular case has a consistent timeframe. In the cases of the killing of Archbishop Isaías Duarte and the attack against El Nogal club, quarterly time periods are used. For the failed attack against Fernando Londoño, a monthly timeframe is used. Each case study chapter and the related appendixes include details of these timeframes.

E.   CHAPTER SUMMARY

This chapter defined the methodology used for this research. It began by outlining the justification for selecting the case studies, and followed with descriptions of the data and information collection processes. It also explained the use of the technological tools that facilitate data manipulation and their analysis. Finally, it indicated that a particular methodology for this thesis is social network analysis.

III.   ISAÍAS DUARTE CASE STUDY

This chapter describes the alliance between the FARC and the criminal organization that assassinated Roman Catholic Archbishop, Isaías Duarte. It is divided into three sections. The first details the history and context of the homicide. Several sources helped to reconstruct the facts of the case. 41 time periods were identified, each one representing one quarter of a year. These have been compressed into nine critical moments and are summarized in Table 3.[64]

Table 3.   Isaías Duarte network. Relates 9 critical moments with 41 periods of time.

Critical Moment	Timeline	Dates
1	1–2	January 2002–June 2002
2	3	July 2002–September 2002
3	4	October 2002–December 2002
4	5–9	January 2003–March 2004
5	10–19	April 2004–September 2006
6	20–28	October 2006–December 2008
7	29–38	January 2009–June 2011
8	39–40	July 2011–December 2011
9	41	January 2012 and beyond

The second part of the chapter is an exploratory analysis of the network's members. It focuses on the behavior of actors in the overall network, particularly through their centrality measures and their evolution over time. The analysis includes measures of degree, eigenvector, betweenness, and closeness centrality.[65]

The third part analyzes the network's social structure and its transformation overtime, paying particular attention to its provincial-cosmopolitan

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[64] Details of the timeline are available in Appendix 1.B.

[65] UCINET software calculated the measures of centrality. See Borgatti, Everett, and Freeman, 2000, *UCINET 6 for Windows.*

and hierarchical-heterarchical dimensions. As part of this analysis, it utilizes SNCD in order to determine if and when significant changes in the network's level of centralization occurred.[66]

A.   BACKGROUND AND CONTEXT OF THE HOMICIDE

On March 16, 2002, the Archbishop of Cali, Colombia, Isaías Duarte Cancino, was assassinated.[67] It occurred after he concluded a Eucharistic celebration in downtown Cali. When he was leaving the premises, he was shot by two individuals who also wounded another priest. Subsequent investigations point to the FARC as the mastermind of the assassination. According to several media reports, a prominent mid-level commander of the FARC, identified in this chapter as PC-FCCO, approved a plan to subcontract a criminal group to execute the operation.

It is likely that the organizational and personal interests of PC-FCCO served as motivations to carry out the operation. The organizational interests date back to the time in which Archbishop Duarte was the head of the Roman Catholic Church in the northern Colombia departments of Antioquia, Córdoba, and Urabá. Because of his ecclesial role, he formed ties with members of the *Autodefensas Unidas de Colombia* (AUC) (or United Self-defense of Colombia in English),[68] which led the FARC to see him as an ally of the *paramilitaries* who oppose the FARC. In terms of personal motivations, the AUC kidnapped one of PC-FCCO's close relatives, so PC-FCCO reached out to Archbishop Duarte to help get him released, but Duarte was either unwilling to approach the AUC or simply unsuccessful. Either way, PC-FCCO turned on Duarte and directly

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[66] Carley, *Organizational Risk Analyzer.*

[67] *El Tiempo*, "Sicario Salió 72 Horas De Cárcel Para Matar a Monseñor Duarte" [Murderer let out 72 hours from jail to kill monsignor Duarte], http://www.eltiempo.com/archivo/documento/MAM-5160703.

[68] Caracol Radio, "Monseñor Duarte Cancino Tuvo Contactos Con Las AUC Para Procesos De Paz: Iglesia" [Monsignor Duarte Cancino had contacts with the AUC for peace processes: Church], http://www.caracol.com.co/noticias/actualidad/monsenor-duarte-cancino-tuvo-contactos-con-las-auc-para-procesos-de-paz-iglesia/20100604/nota/1308528.aspx.

threatened him.[69] Two hypotheses have emerged about the plans to kill Duarte. One contends that PC-FCCO used two contacts from a criminal gang to serve as an intermediary for the assassination. The other argues that PC-FCCO ordered another member of his group, JFJ-FCCO, to subcontract the murderers. This thesis considers both.

A series of structural changes occurred in the network following the murder of Duarte. It appears that two major factors caused these changes. The first was the state's operations to arrest the suspected perpetrators of the Duarte killing. The second, which was related to the first, was the killing of those suspects by unknown members of the FARC and the criminal organizations. It is possible that the FARC believed that the knowledge they had about the assassination could have endangered the FARC if they decided to cooperate with authorities.

Figure 1 depicts the overall network linked to the Isaías Duarte assassination. The red nodes represent the FARC members, while yellow, blue, and green nodes represent members of various criminal gangs. There are three important aspects of this graph to consider. The first is that the relationships among its members are communication, kinship, and operational ties. Second, each actor's name has been anonymized. This is also true for the case studies in the next two chapters. Third, the graph provides a general insight into what the structural position of each actor was in the network.[70]

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[69] *El Colombiano*, "Piden Incluir Testimonio En Caso De Monseñor Isaías Duarte Cancino" [to Include testimony in case of Monsignor Isaías Duarte Cancino], http://www.elcolombiano.com/BancoConocimiento/F/farc_tenian_un_movil_para_matar_a_mons enor_duarte_cancino/farc_tenian_un_movil_para_matar_a_monsenor_duarte_cancino.asp.

[70] Appendix 1.A provides a list of open sources used in this research. This chapter does not include all sources as footnotes. However, the sources have been used to understand the context and the relationships between actors of the network over time.
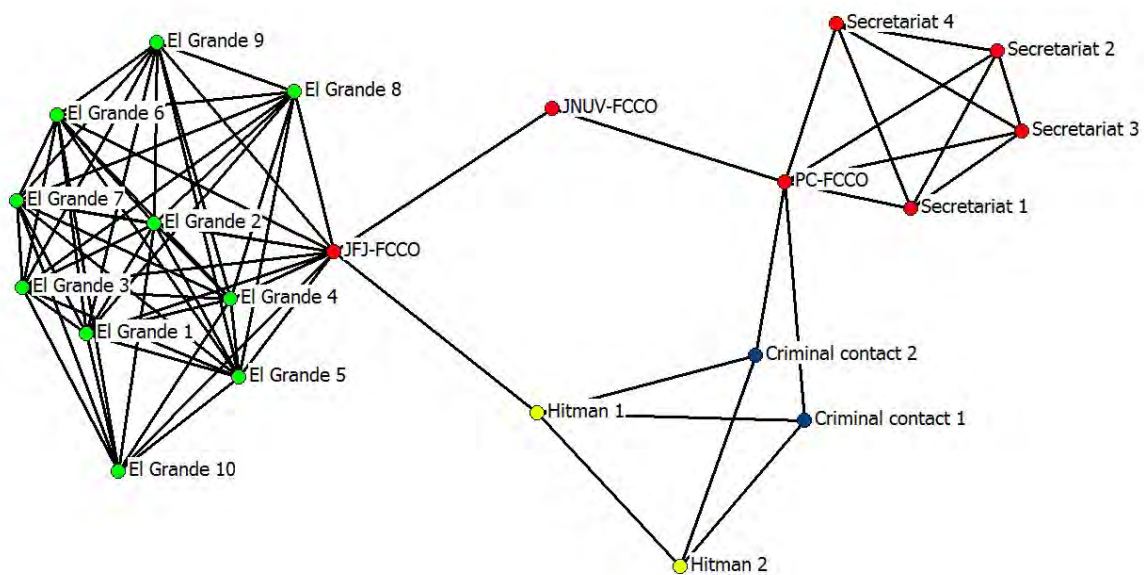
Figure 1.   Overall network linked to the murder of Isaías Duarte.

B.   MEMBERS OF THE TERRORIST AND CRIMINAL NETWORK

The network responsible for the assassination of Archbishop Duarte is relatively small. In its entirety, it consisted of 21 people. Overall, FARC terrorists represent 33.3 percent of members of the network, while 66.7 percent are members of different criminal organizations. Of the network's members, 4.8 percent transitioned from one group to another once they accomplished the initial task. Members of the FARC belong to three distinct organizational levels: The secretariat, from which at least four of its members knew and approved the plan to kill Duarte; two mid-level commanders that judicial investigations found were from the *Comando Conjunto de Occidente* (or Western Joint Command, in English), which operates in the departments of Cauca, Valle, Nariño, and the city

of Cali; and at least one from the organization's grassroots, someone who participated in the subcontracting process with the murderers.[71]

Criminal members of the network belong to at least two different groups. Those who belong to the first organization operated in the sector known as *Sol de Oriente* in Cali. One member of this group was killed afterwards in jail, and the second received a sentence for the crime. It is possible that two other members, acting as liaisons, belonged to a different organization. Nevertheless, research and the data did not provide that information. One of the reasons is that the military forces carried out the operation that led to their arrest and not the Colombian criminal investigation agencies.[72] After their release, they were killed by unknown assailants.

Another set of criminals joined the network when the organization achieved its primary objective. These were ten members of the gang *El Grande*.[73] One of its associates, JFJ-FCCO, is an example of someone who transitioned between organizations. He moved from the FARC to the criminal gang.

Given the network's dynamic nature, it is important to analyze the behavior of actors over time. Centrality measures calculated across 41 time periods contribute to determining each actor's position in the network. This chapter´s introduction noted that nine critical moments compress the entire

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[71] Observatorio de Procesos de Desarme, Desmovilización y Reintegración, *Presencia De Organizaciones Guerrilleras y 'Bacrim' En Territorio Colombiano* [Presence of guerrilla organizations and 'Bacrim' in the Colombian territory] (Bogota, Colombia: Universidad Nacional de Colombia, 2012). This report can be accessed through the website: http://www.observatorioddr.unal.edu.co/productos_academicos/nuevos/oddr_presenciadeguerrill as_ybacrim.pdf

[72] *La Vanguardia*, "Detienen Al Jefe De Una Banda De Sicarios Por El Asesinato Del Arzobispo De Cali" [Arrested boss of a murderer's gang for the killing of Cali's archbishop], http://www.lavanguardia.com/internacional/20020326/51262752148/detienen-al-jefe-de-una-banda-de-sicarios-por-el-asesinato-del-arzobispo-de-cali.html#ixzz38KjFFXDm.

[73] Fiscalía General de la Nación, "Fallo Condenatorio Contra Miembros De La Banda 'El Grande'" [Conviction on members of gang 'El Grande'], http://www.fiscalia.gov.co/colombia/noticias/fallo-condenatorio-contra-miembros-de-la-banda-el-grande/.

timeline.[74] Degree centrality identifies which actors had the greatest number of ties during each period.[75] Only with the exception of the time of the alliance with *El Grande,* the FARC members exert a larger influence because of their communications capabilities and decision-making process. This reflects the networks mesh shape type, where members of *El Grande* are connected to each other. The mesh network contributes to the decision-making process making it collegial; therefore, there is consensus or majority approving the execution of crimes and terrorist events.

Eigenvector centrality is a relevant measure when one compares the highest score of an actor with nodes that register half or less.[76] For these scores, members of the FARCs secretariat and the mid-level commander in charge of the assassination have equivalent measures, which are double the members' scores with tactical roles. Members with the highest eigenvector scores are part of the strategic level of the organization.

The betweenness centrality measures indicate that brokerage processes were dominated by the FARC.[77] In 88.8 percent of the time periods, members of the FARC were in positions of brokerage that allowed them to control the flux of resources and influence decision making. The network's evolution highlights the position of actor PC-FCCO, who is an important mid-level commander of the FARC in western Colombia. His position as a broker facilitated the proposition of his plan to the FARC's secretariat; similarly, he oriented members of his group to plan and execute the homicide with elements of criminal gangs.

One might interpret the position of brokerage as a role of accountability by which the actor has to inform his superiors of advances on terrorism and criminal plans. This position could contribute to the security of terrorist group members of

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[74] Appendix 1.C provides a list of the top ten actors with their centrality measures over time.

[75] Freeman, "Centrality in Social Networks Conceptual Clarification," 219.

[76] Borgatti, Everett and Johnson, "Analyzing Social Networks," 168–169.

[77] Freeman, "Centrality in Social Networks Conceptual Clarification," 224.

the relevant hierarchical level. In other words, PC-FCCO assumed the responsibility not only for the outcome of the operation, but also for any negative consequences that could be derived from it. Fortunately for him, the results of these operations contributed to PC-FCCO's eventual rise to become a member of the FARC's secretariat.

Closeness centrality is another measure dominated by the FARC portion of the network.[78] The scores indicate that PC-FCCO has the potential to reach other members within the network in relatively quicker manner than others and he has access to information and other resources that keep the group alive. They also identify JFJ-FCCO as a potential key actor, who during periods 20 to 28 (October 2006–December 2008) served as a key link of *El Grande* with two of the FARCs mid-level commanders: PC-FCCO and JNUV-FCCO. Although he belonged to the FARC, he had a deeper connection with a criminal gang. However, during his transition from the FARC to *El Grande* he contributed to the terrorist organizations interests. Table 4 shows the top eight actors' normalized centrality measures sorted by highest value.

Table 4.   Top eight actors' normalized centrality measures in the
Isaías Duarte murder overall network.

No	Degree (norm.)	Closeness (norm.)	Betweenness (norm.)	Eigenvector (norm.)
1	JFJ-FCCO (60)	JFJ-FCCO (62.5)	JFJ-FCCO (53.4)	JFJ-FCCO (44.6)
2	El Grande 1–6 (50)	JNUV-FCCO (51.282)	PC-FCCO (35.2)	El Grande 1–7 (43.7)
3	El Grande 7–10 (45)	Hitman 1, El Grande 1–7 (50)	JNUV-FCCO (28.9)	El Grande 8–9 (40.3)
4	El Grande 10 (40)	El Grande 8, 9–PC-FCCO (46.5)	Hitman 1 (17.7)	El Grande 10 (36.1)
5	PC-FCCO (35)	El Grande 10 (45.455)	Contact 1 and 2 (2.8)	Hitman 1 (4.7)
6	Secretariat 1–4, and Hitman 1 (20)	Contact 1–2 (42.5)	Hitman 2 (0.17)	JNUV-FCCO (4.6)
7	Contact 1, 2–Hitman 2 (15)	Hitman 2 (38.4)	El Grande 1–7 (0.13)	PC-FCCO (0.6)
8	JNUV-FCCO (10)	Secretariat 1–4 (33.8)	--	Contact 1 and 2 (0.6)

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[78] Ibid., 224.

C. TOPOGRAPHICAL DIMENSIONS OF THE OVERALL NETWORK

The overall network tends to lie in the provincial dimension of network topography.[79] Average degree centrality is 6.95 and the clustering coefficient is 0.89. This latter indicates that a segment of the network is highly dense, which corresponds to the relations of actor JFJ-FCCO, who belonged to the FARC and transitioned to the Cali criminal gang afterwards. Furthermore, the network seems to have been well connected and was able to manage resources efficiently due to its small world quotient that reached a score of 2.55.

The network also tends to be heterarchical in terms of the hierarchichal-heterarchical dimension of network topography.[80] The various centralization results are relatively low. For instance, degree centralization equals 27.89 percent, eigenvector 29.44 percent, and closeness 39.34 percent. Betweenness equals 49.03 percent, suggesting that one actor was in a position of brokerage, above every other actor. This score identifies actor PC-FCCO as the one with the highest centrality score. Table 5 summarizes centralization scores of the overall network.

Table 5.   Summary of centralization scores for the Isaías Duarte murder overall network.

CENTRALIZATION MEASURES	SCORES
Degree centralization	27.89 percent
Eigenvector centralization	29.44 percent
Closeness centralization	39.34 percent
Betweenness centralization	49.03 percent

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[79] Everton, "Network Topography, Key Players, and Terrorist Networks," 13.

[80] Ibid., 15.

Standard deviation identifies betweenness centrality as the measure with the largest variation. Actors in the overall network obtained scores with a range between 0.00 and 53.47; the normalized mean is 6.77, and its standard deviation is 14.32. These scores suggest that the actor with the highest centrality is in the fourth positive standard deviation. Table 6 summarizes the standard deviation scores.

Table 6.   Summary of scores of centrality measures variability in the Isaías Duarte murder network.

STANDARD DEVIATION	SCORES
Degree standard deviation	3.20
Eigenvector standard deviation	20.73
Betweenness standard deviation	14.32
Closeness standard deviation	9.71

D.   THE NETWORK'S EVOLUTION OVER TIME: A LONGITUDINAL ANALYSIS

This network emerged when the FARC subcontracted members of criminal groups to carry out the assassination. The ties suggest that the FARC and the criminals had a formal, superior-subordinate type of relationship. This type of relationship could have facilitated communication from the FARC to the criminal group. With the objective of visualizing this change in the networks topography, the timeline was compressed into nine critical moments, which are directly related to the end of social ties among the members. Figures 2, 3, 4, and 5 show the centralization of the network in relation to the standard deviation of each moment.[81]

During the first time period, this alliance appears to have maintained a balance within the hierarchical-heterarchical dimension. Specifically, degree

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[81] Appendix 1.D provides a table with topographical measures and centralization of the network in critical moments. Likewise, Appendix 1.E provides a visualization of the network's transformation over time.

centralization was 37 percent, eigenvector centralization was 52.96 percent, betweenness centralization was 55.33 percent, and closeness centralization was 48.20 percent. Similarly, the network appears to have maintained a balance on the cosmopolitan-provincial dimension of network topography. The network had an average degree of 3.6 and a clustering coefficient of 0.58. These results suggest that the network had an important mixture of strong and weak ties that facilitated communications and the flow of resources through the network.

Subsequently, between March and October 2002 (time periods 1 to 4 on the timeline), a series of counter-network operations led to the detention of members of the network. During those months, five members were arrested because of their involvement in the crime. Moreover, a member of the FARC's secretariat, who was one of the superiors to approve the plan, died from natural causes. On the other hand, three of the prosecuted criminals were killed under different circumstances. One was murdered in jail and two were shot once they were released. It is important to highlight that from the five members, four are elements of criminal groups allegedly responsible for the homicide. Just one criminal survives and is currently serving a jail sentence. The fifth member arrested was JFJ-FCCO. He was sentenced in January 2005, but was released in October 2006 by a criminal court that reviewed the testimony against him. In November 2008 he was arrested again due to his ties to hired killings. In May 2011, he was killed by unknown murderers in a rural area 30 kilometers south of Cali.

The death of the perpetrators and the tactical broker of the FARC could have a strategic impact that strengthens the physical and legal security of the FARCs commanders. Once the organization accomplished its primary objective it began to deteriorate. Between time periods 2 and 19 (March 2002 and September 2006), the network lost five members (three out of four were killed and one of FARCs high-level member was dead), which affected the level of centralization, transforming the group into a more heterarchical organization, while at the same time seeing greater levels of clustering.

Between time periods 20 and 28 (October 2006 and December 2008), the network grew because of the actions of one actor who formed a new alliance with the criminal gang *El Grande*. This analysis highlights JFJ-FCCO as an actor with the objective of being in a position of brokerage between the FARC and criminal organizations in Cali. The new criminal association impacted the levels of centralization, which reached lower levels and higher variability in actors centrality. During times periods 29 and 41 a transformation can be observed lasting until the network's dissolution. However, this dissolution is not complete because of two factors. First, the remaining members were exclusively from the FARC. Second, the end of every relationship was caused by operations of the Colombian armed forces, which were promoted not only because of the death of Archbishop Duarte, but because of crime group's overall criminal activity.
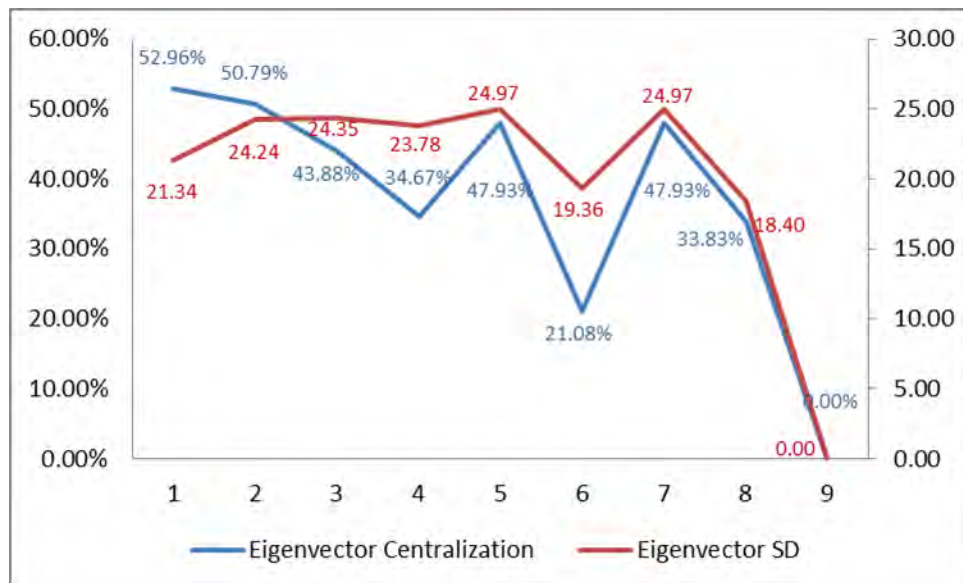
Figure 2.   Longitudinal scores of eigenvector centralization and standard deviation (Isaías Duarte murder network).
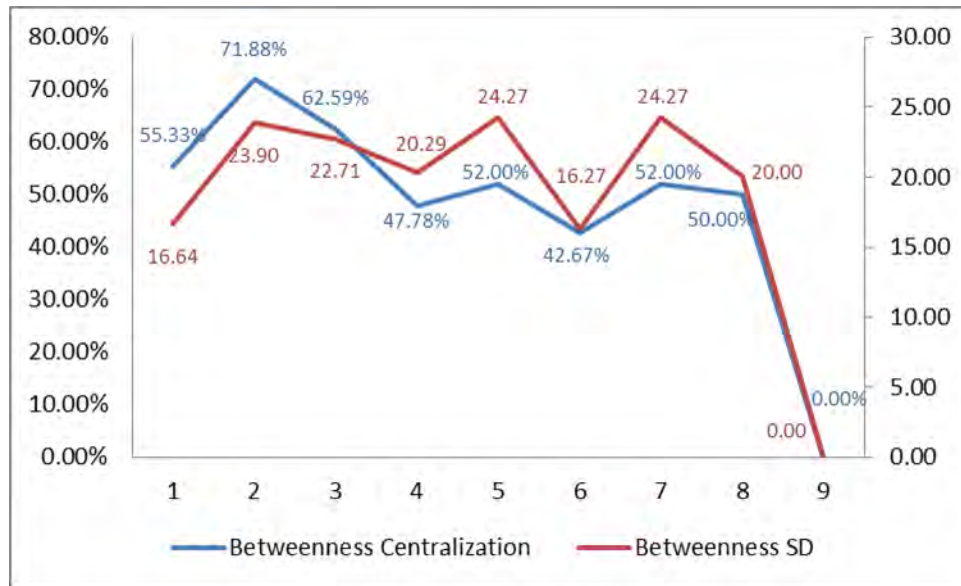
Figure 3. Longitudinal scores of betweenness centralization and standard deviation (Isaías Duarte murder network).
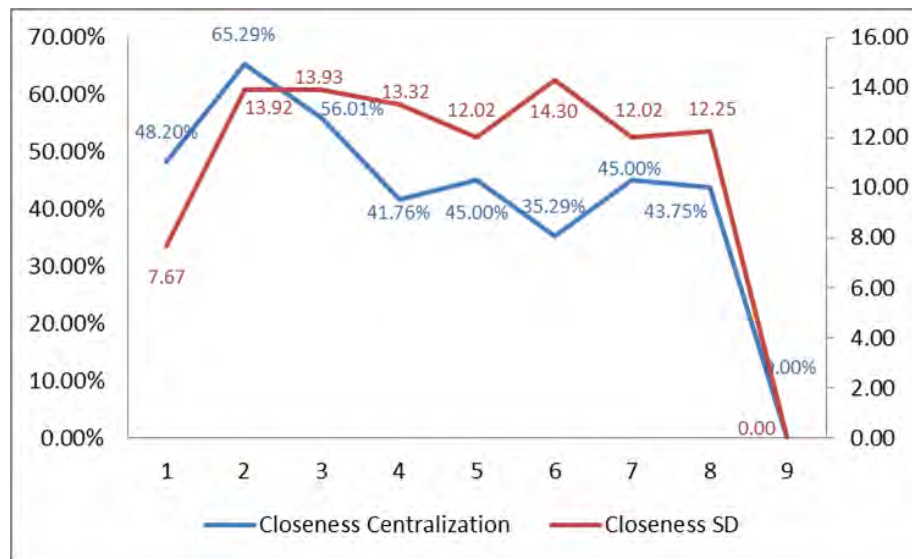
Figure 4. Longitudinal scores of closeness centralization and standard deviation (Isaías Duarte murder network).
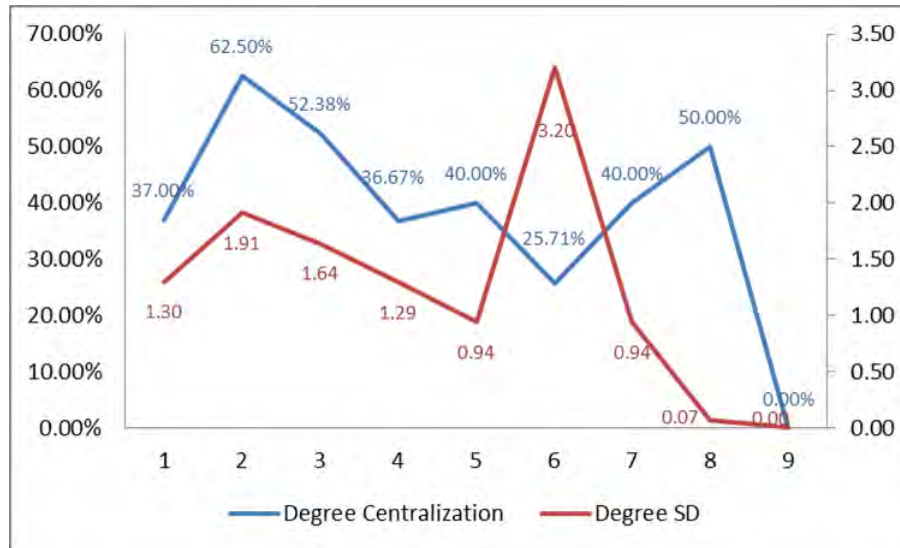
Figure 5. Longitudinal scores of degree centralization and standard deviation (Isaías Duarte murder network).

Overall, the measures show a process of decentralization starting at the second critical moment between July and September 2002. This downward trend reaches its lowest point at the sixth critical moment (October 2006–December 2008), which is the period when JFJ-FCCO was released from jail, formed alliances with *El Grande*, and was then arrested due to his ties with that gang. One interesting feature is the spike of degree centrality standard deviation at the sixth critical moment, which suggests that the network became more hierarchical because most of the actors had the same number of ties. In fact, 62.5 percent of the actors were within the first standard deviation.

1. Social Network Change Detection

SNCD can help identify significant changes of centralization in the network.[82] Figure 7 indicates that a significant change coincides with point 19 of the timeline.[83] At that moment the terrorist group generated a new alliance with

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82 McCulloh and Carley, *Social Network Change Detection*, 1–20.

83 Significant changes are detected when measures cross a threshold, in this case a default score provided by ORA (i.e., 0.01/3.5). For further explanation see Sean F. Everton and Dan Cunningham, "Detecting Significant Changes in Dark Networks," *Behavioral Sciences of Terrorism and Political Aggression* 5, no. 2 (2013): 103; Everton, *Disrupting Dark Networks*, 332.

the criminal organization, *El Grande,* which affected the networks centralization considerably. In a reciprocal manner, one can observe the increasing measures of clustering coefficient at time 19. The clustering coefficient identifies a segment of the highly connected network.[84]
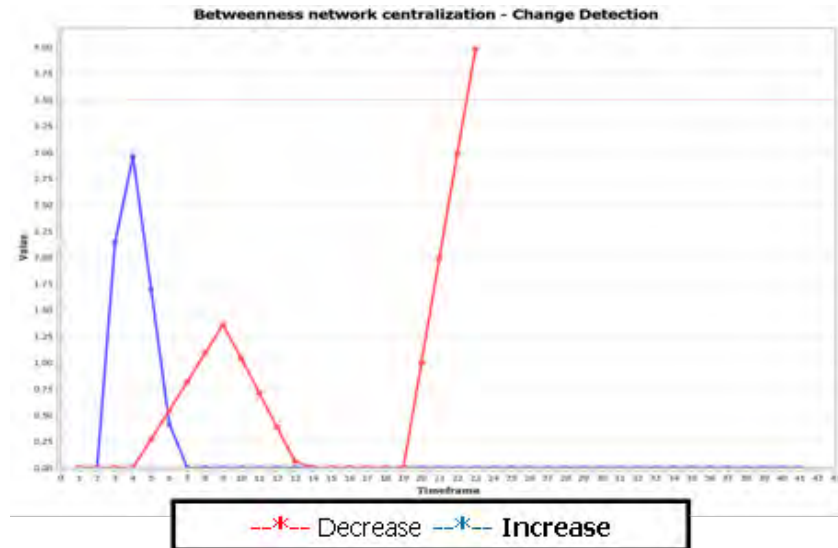
Figure 6.   SNCD reflects decreasing of betweenness centralization at time 19 (Isaías Duarte murder network).

E.   CONSIDERATIONS FOR THE ISAÍAS DUARTE CASE STUDY

This case contributes to our understanding of the behavior of the FARC with respect to their subcontracting with criminal organizations. It is important to consider the security context that influences the FARC's. Among the essential aspects of the Colombian context, the conflict between the FARC and the AUC was an important factor to foster a spiral of violence in the country in the early 2000s.

The formation of terrorist-criminal alliances proved to be an effective measure that helped fulfill an objective that, in turn, would not risk the physical and legal security of its members. It took advantage of endogenous factors to link

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[84] Appendix 1.F provides graphs that support these statements. Graphs were obtained using ORA.

temporary members of criminal gangs. The validity of this alliance is enforced only by the existence of ties between nodes of each group. For this particular case, the relations ended with the death of some of the actors who could have actively participated in the fulfillment of the FARC's objective. This research does not suggest that the terrorist organization is responsible for the death of the former members of the network. Nevertheless, their demise favored the prevalence of nodes that have endured over time and that have reached transcendent roles in this terrorist group.

The centrality measure results highlight the positions of the FARCs terrorists as active individuals within the network. Independently of their stalemate before the assassination of the Archbishop, their position in the network allowed them to influence and maintain control of resources within the organization.

The centralization results indicate that the network tended to be heterarchical. However, there are moments in which their scores position the group into the middle point of that dimension where they become more flexible. Networks less centralized could reach two stages. One is that the flux of communication from the FARC towards its allies remains at the level of superior-subordinate type. The other is the potential loss of control of the subcontracted group, which can be a definitive factor in finishing any ties with criminal groups in a shorter period.

The FARC took advantage of this alliance to fulfill an organizational objective. However, their actions could be oriented to spark relationships for short periods of time and subsequently end them after they do not need them any longer. The following chapter analyzes another case of criminal alliance in 2003, promoted by one of the most violent groups within the FARC.

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IV. EL NOGAL TERRORIST ATTACK CASE STUDY

This chapter analyzes the terrorist and criminal association that conducted an attack on the El Nogal club. It has a similar structure to the previous one. First, it describes the alliance between the FARC and the criminal group that carried out this terrorist attack. Drawing on several sources it builds a timeline of 38 time periods that help in understanding the network's dynamics. Every period represents a quarter of the year, and in this case, it is compressed into 12 critical moments. The sources shed light on the relationships between actors of the network and their evolution over time. Table 7 summarizes the relationship between critical moments and particular time periods.[85]

Table 7.   Relation between 12 critical moments and 38 time periods of the timeline—El Nogal attack network.

Critical moment	Timeline	Dates
1	1–2	January 2002–April 2003
2	3–4	May 2003–October 2003
3	5	November 2003–January 2004
4	6–7	February 2004–July 2004
5	8–12	August 2004–October 2005
6	13–21	November 2005–January 2008
7	22	February 2008–April 2008
8	23–28	May 2008–October 2009
9	29–32	November 2009–October 2010
10	33–34	November 2010–April 2011
11	35–37	May 2011–January 2012
12	38	February 2012 and Beyond

Next, it describes the members of the network. The analysis focuses on the behavior of actors in the overall network and their behavior during its

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[85] Appendix 2.A provides a list of open sources used in this research. Details of the timeline are available in Appendix 2.B.

evolution, using the same four measures of centrality described previously: degree, eigenvector, betweenness, and closeness centrality.[86] Finally, it analyzes the network's social structure and its transformation over time, paying particular attention to its provincial-cosmopolitan and hierarchical-heterarchical dimensions. As part of this analysis, it utilizes SNCD in order to determine if and when significant changes in the network's level of centralization occurred.[87]

A.   BACKGROUND AND CONTEXT OF THE ATTACK ON EL NOGAL

In February 7, 2003, the FARC executed a terrorist attack against the El Nogal club in Bogotá, leaving 36 dead and 164 injured. The FARC's Mobile Column Teofilo Forero (CMTF) subcontracted with members of a criminal gang from Bogotá, many of whom were family of CMTF members. Among the terrorists involved was JFAZ, who had access to the club because of his role as squash instructor. Judicial investigations and the media identified HDVSAP as the terrorist in charge of setting up the operation. The motives that led the FARC to carry out this attack could be related to what some journalistic analyses have revealed about the club, which the FARC saw as an "oligarchy symbol" of Colombia. Likewise, given the country's security context at the time, the attack added to a series of terrorist and criminal activities that the FARC planned and executed in major urban areas in the country.

The FARC used a diverse set of members to carry out key logistical and operational functions for the attack. It was primarily in charge of logistics and planning; however, members of the criminal gang were exclusively in charge of its execution. According to judicial testimonies and the press, members of the FARC decided that during the attack, or shortly thereafter, the criminals had to be killed in order to unlink the terrorist organization from any legal responsibility. During the attack, two terrorists of the criminal gang died. A third member, however, did not enter to the premises of the club during the attack; he was

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[86] Borgatti, Everett, and Freeman, *UCINET 6 for Windows.*

[87] Carley, *Organizational Risk Analyzer ORA.*

arrested later and now is serving a 38-year prison sentence. The reconstruction of the event allowed the authorities to identify the people responsible for this alliance that has been disrupted by the Colombian authorities.

After the attack, the FARC tried to use the network's logistic structure in order to execute other terrorist attacks in Bogotá. One of these targeted the military hospital in the northern zone of the capital city. This allowed intelligence analysts to locate and arrest other members of the network, which ultimately caused it to disperse to different parts of the country. This made it more difficult to arrest members of the FARC, but it also probably decreased terrorist attacks at that time. Figure 8 depicts the overall network linked to the El Nogal attack. Nodes in red are members of the FARC, in blue are members of its urban militia, and yellow are members of the criminal gang. The ties among actors are organizational (relationships among members of the same organization), operational (ties between actors participating in the same events), communications, and kinship.
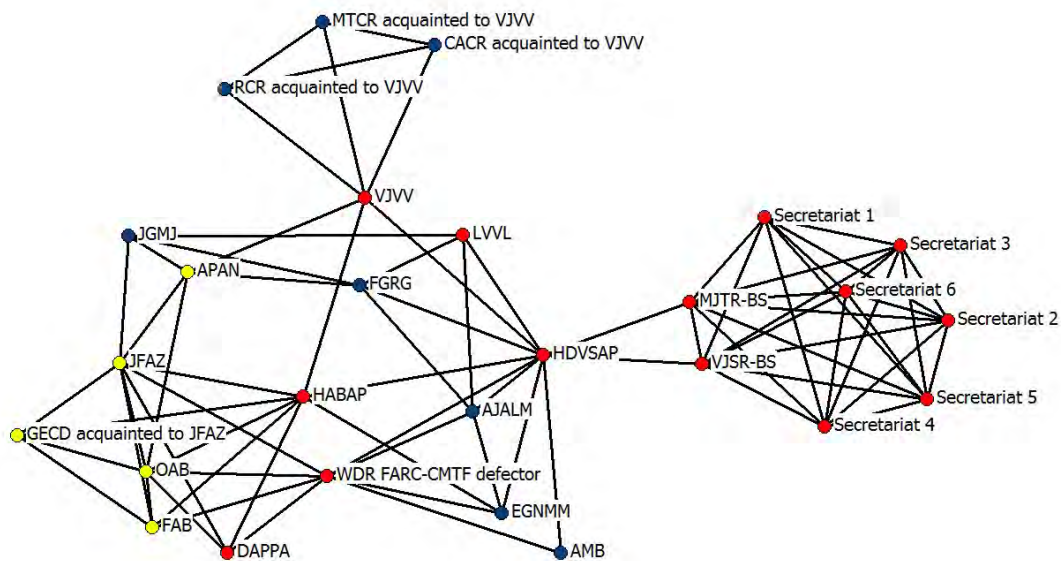
Figure 7.   Overall network linked to the terrorist attack on the El Nogal club in Bogotá.

The overall network responsible for this attack is relatively small. Twenty-seven people played a role, of which 81.5 percent (22) belonged to the FARC and 18.5 percent (5) to the criminal gang. These percentages indicate the importance this terrorist operation had for the FARC. The number of people within the FARC could indicate two things. First, members with different expertise and levels of command contributed to the fulfillment of the terrorist objective. Second, the diversification of members had the purpose to compartmentalize the organization, so everyone knew only a part of the general plan.

The most important person, HDVSAP, was a member of the FARC. He presented a plan to his immediate superiors, MJTC-BS and VJSR-BS, who, along with six other members of the secretariat, approved the operation. Other FARC members who belong to the CMTF were responsible for the acquisition, transportation, and employment of explosives in a vehicle. Other members of the group, what the FARC calls the urban militias, were responsible for organizing the logistics and mobilization in the country's capital city. The second set of actors is the subcontracted criminal organization. They used their access to the club's premises to elaborate a plan regarding timing and placement of the IED.

The FARC financed two activities in order to prepare the attack. First, they convinced JFAZ and his relatives to upgrade a family business with the objective of purchasing an asset who had the opportunity to become a member of the club. Second, they gave money to JFAZ in order to buy a new vehicle to load with explosives and facilitate their unsuspected access into El Nogal's premises. Some analysis suggests that these financing operations cost nearly 80 million Colombian pesos.[88] The FARC financed other activities, such as the means of transportation, the acquisition, mobilization, and adaptation of explosives, the

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[88] According to Colombian financing services the exchange rate for the time was nearly $2,963.28 pesos per dollar. These operations had an approximate cost of $26,997.11 U.S. dollars. This information was drawn from Banco de la República, "Serie Histórica - Tasa De Cambio Representativa Del Mercado (TRM)" [Historical series - representative market exchange rate], http://www.banrep.gov.co/es/trm.

rental of the workshop and other actions involving the subcontracted criminal gang.

A CMTF member had supervised and coordinated the attack. This person, identified as VJVV, concentrated the actors' capacities around the criminal organization and the workshop. He did not have an exclusive contact with HDVSAP to whom he must render accounts for the plan's development, which suggests that many members were commissioned directly by HDVSAP; therefore, communication channels were not empowered to just one actor in Bogotá. One might assume that HDVSAP preferred to have open possibilities to get in touch with members of the network. Openness gave him the capacity to intervene on decisions about critical matters in order to fulfill the objectives of the attack. The influence of FARC members in the network is clear when one examines their centrality measures.

B.   MEMBERS OF THE TERRORIST AND CRIMINAL NETWORK

The development of individual activities, as well as the decision to murder members of the criminal organization, appears to have influenced the relative importance of FARC members within the network.[89] The centrality results demonstrate this. During the first moments of this alliance, HDVSAP and HABAP had the largest amount of connections—the former because of his direct communication with the FARC's secretariat; the latter, because of his kinship ties with members of the criminal group. With the elimination of the criminal group, HDVSAP and VJVV lost many of their network ties. The decision to kill the criminals could have generated fear among the remaining actors, and this could have led to the gradual arrests of the remaining network members. Table 8 presents the overall network top eight actors ranked by normalized centrality scores.

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[89] A detailed report of centrality measures of the top ten actors over time is available in Appendix 2.C.

Table 8.   Overall centrality measures in the El Nogal attack network.

No	Degree (norm.)	Closeness (norm.)	Betweenness (norm.)	Eigenvector (norm.)
1	HDVSAP (38.4)	Hdvsap (61.9)	Hdvsap (54.6)	Mjtr-BS and Vjsr-BS (50.8)
2	Mjtr-BS, Jfaz, Vjsr-BS, Habap, and Wdr (30.7)	Habap (52)	Vjvv (22.8)	Secretariat 1–6 (48.3)
3	Secretariat 1–6, and OAB (26.9)	Jvv (50)	Mjtr-bS and Vjsr-BS (17.5)	Hdvsap (20.70
4	VJVV (23.07)	Wdr (49.05)	Habap (15.8)	Wdr (7.5)
5	Ajalm, Apan, Fgrg, and Fab (19.2)	Mjtr-BS and Jjsr-BS (48.14)	Wdr (10.4)	Habap (7.2)
6	Egnmm, Gecd, Dappa, Jgmj, And Lvvl (15.3)	Ajalm (45.6)	Apan (4.15)	Ajalm (6.2)
7	Cacr , Mtcr, and Rcr (11.5)	Egnmm and Fgrg (44.06)	Jfaz (3.9)	Egnmm (5.8)
8	AMB (7.6)	Jfaz (42.6)	Fgrg (3.7)	Fgrg (5.3)

In terms of eigenvector centrality, it is important to highlight the relationship between HDVSAP and the FARC's secretariat. Among the highest members within the formal hierarchy, their eigenvector scores are the same. As noted previously, this measure is significant when one compares the highest score with the second higher, if the latter is half or less than the first actor.[90] In the case of HDVSAP, he represents an important finding for this investigation. He has conducted large terrorist events that damaged different sectors of the Colombian society,[91] which have benefited the FARC over a long period. However, he has not risen to upper echelons of the organization and has remained a tactical operator within it. This analysis cannot identify the real causes that prevent him from becoming a member of the secretariat, but one could argue that his abilities only satisfy the operational requirements of the FARC and do not reflect a strong strategic capability. For example, his use of

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[90] Borgatti, Everett, and Johnson, "Analyzing Social Networks," 168–169.

[91] *El Espectador*, "'El Paisa', Un Objetivo Clave" ['El Paisa', a Key Target], http://www.elespectador.com/noticias/judicial/el-paisa-un-objetivo-clave-articulo-421782.

violence might be seen as a detriment to the long-term strategic objectives of the FARC in the political arena.

With respect to betweenness centrality, one can observe actors' dynamics in two broad phases.[92] The first identifies FARC members HDVSAP, VJVV, and HABAP as actors in position of brokerage. HDVSAP controls information flux between the FARC's secretariat and the rest of the organization. VJVV coordinates the attacks planned to strike Bogotá, and HABAP is a FARC member with kinship ties with the criminal group. The position of brokerage dissipates from the moment of the terrorist attack, and changes completely with the arrest of VJVV in the year 2004 and HABAP in 2011. The second phase begins with the security agencies' actions against the network and later with the death in action of VJSR-BS. These events indicate that intermediation power returns to a superior level of the hierarchy, which is the level that decides what actions HDVSAP can perform with his terrorist subgroup.

Closeness centrality can help to identify the extent to which FARC secretariat members exerted control over the network.[93] HDVSAP's superiors, MJTR-BS and VJSR-BS, are in a position that allows them to access resources quickly. One could argue that, although the attack's operational control was in the mid-level commander's hands, the secretariat had resources to intervene at any time. Similarly, the secretariat could have asked anyone in the network to render accounts. Nevertheless, this argument could fall short considering that this analysis does not consider actors who are part of the FARC but not a part of this operation. These actors could influence the access to resources, particularly information going to the hierarchical level.

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92 Freeman, "Centrality in Social Networks Conceptual Clarification," 224.

93 Ibid., 224.

C. TOPOGRAPHICAL DIMENSIONS OF THE OVERALL NETWORK

The overall network tends to lie in the cosmopolitan dimension in that it is relatively sparse.[94] The overall organization had a density of 0.22, and an average degree of 5.78. When one compares these metrics with the Isaias Duarte's network (i.e., provincial dimension), one finds that its average degree was 6.95 and the clustering coefficient reached 0.89, suggesting higher connectivity in the Duarte example. On the other hand, El Nogal network was not highly connected and, in order to be effective, it had to rely on weak ties to bridge clustered segments. The existence of weak ties from the general structure of the organization helps in identifying four subgroups: the FARC's secretariat, mid-level commanders, militias, and the criminal organization members. Actors from these segments had a power of brokerage that kept the network connected.

The network appears to lie in a middle point between the heterarchical and hierarchical dimension.[95] One can see that the centralization measures are relatively low, except for betweenness centralization, which reaches 50.72 percent. In this sense, HDVSAP and MTSR-BS have the highest scores of centrality. This measure suggests that these actors had a brokerage potential in the network. This condition is related to the exit of ten actors during the first five periods on the timeline, which correspond to the following 15 months after the attack. Table 9 summarizes centralization scores of the overall network.

Table 9.   Summary of the overall El Nogal attack network's centralization.

CENTRALIZATION MEASURES	SCORES
Degree centralization	17.54 percent
Eigenvector centralization	42.45 percent
Closeness centralization	38.02 percent
Betweenness centralization	50.72 percent

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94 Everton, "Network Topography, Key Players, and Terrorist Networks," 13.

95 Ibid., 15.

An alternative centralization measure is the variance (standard deviation) in actors' centrality. Particularly the attention of this analysis focuses on betweenness centrality. In the overall network actors had scores in a range of 0.00 to 54.65, with a mean of 5.81 and a standard deviation of 11.59. These figures suggest that the margin of variance was large, and actors with the largest scores had a peculiar power above the rest. These results compared to the Isaias Duarte case study indicate that the Londoño attack network had low levels of variation, suggesting that the network is more heterarchical than the network in the Isaias Duarte case. Table 10 summarizes the Londoño attack network standard deviation results.

Table 10.   Summary of alternative measures regarding the network's standard deviation.

STANDARD DEVIATION	SCORES
Degree standard deviation	2.01
Eigenvector standard deviation (norm.)	20.9
Betweenness standard deviation (norm.)	11.59
Closeness standard deviation	6.49

D.   THE NETWORK'S EVOLUTION OVER TIME: A LONGITUDINAL ANALYSIS

The network began its activities with high-levels of betweenness centralization. One can highlight HDVSAP's structural position because, at least at the earliest phase of operations, he controlled the flow of resources. Communications between his superiors and subordinates contributed to his capacity for decision making and for transmitting orders efficiently. Similarly, he had the potential to interact with other members who had specific tasks. During the times 2 through 5, which correspond to the following months after the attack (February 2003 until January 2004), the organization betweenness centralization increased even more. One could interpret this as a result of HDVSAP's activities to seek further control over terrorist plans. One could also argue that when the

FARC pretended to execute other terrorist events with the same resources, this decision led to the failure of some of the other ongoing projects.

Between the time periods 6 and 32 (February 2004 until October 2010), several important changes occurred in the network. This was seven years after the attack (i.e., February 2003) and may indicate that when it accomplished its primary objective, its actors' priorities and objectives changed. One might argue that exogenous factors influenced the network, particularly from the action of the state, were only relevant during the first year after the attack. Subsequent changes are consistent with the Colombian armed conflict dynamic. The state's actions were oriented to punish the organization responsible for the El Nogal attack, but their arrests or deaths were more related to other criminal and terrorist events performed during their trajectories within the FARC.

Two characteristics are observable during the network's transformation from February 2004 and October 2010. First, the relationships between actors were more homogenous, which suggests there was not an actor who had potential power of brokerage to influence the decision-making process or to manipulate resources. Second, the increase in closeness centralization may indicate that an actor or small set of actors had a larger capacity to access resources in the network reciprocally. However, closeness centralization reached its highest point (48.16 percent) between periods 13 to 21, which corresponds to the time authorities arrested two terrorists (November 2005 to January 2008). One belonged to the criminal organization that did not enter the club, and the other, a FARC member arrested in the Colombia's southern border, was responsible for the acquisition of explosives.

Between time periods 33 and 38 (November 2010 and beyond January 2012), the network shrank to just include FARC members. Without the participation of members of other organizations and with the exit of FARC members of the tactical level, the network remained integrated by radical members and the highest hierarchical level. Reduction of ties between actors influences degree centralization, which is not necessarily a logical consequence

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of the reduction, but it might be related to actors belonging to the same cluster. Figures 8 to 11 identify the variation of centralization regarding the standard deviation of each critical moment.[96]
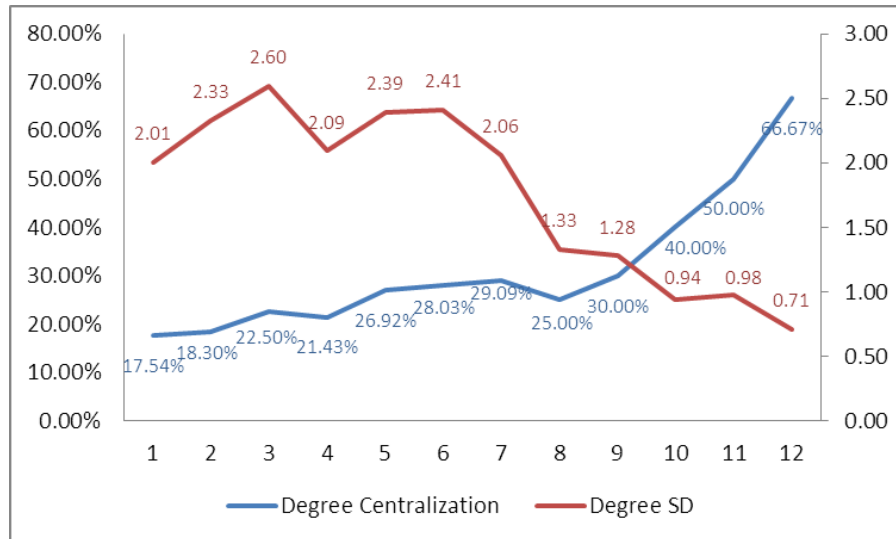
Figure 8.   Longitudinal scores of degree centralization and its standard deviation in the El Nogal attack network.
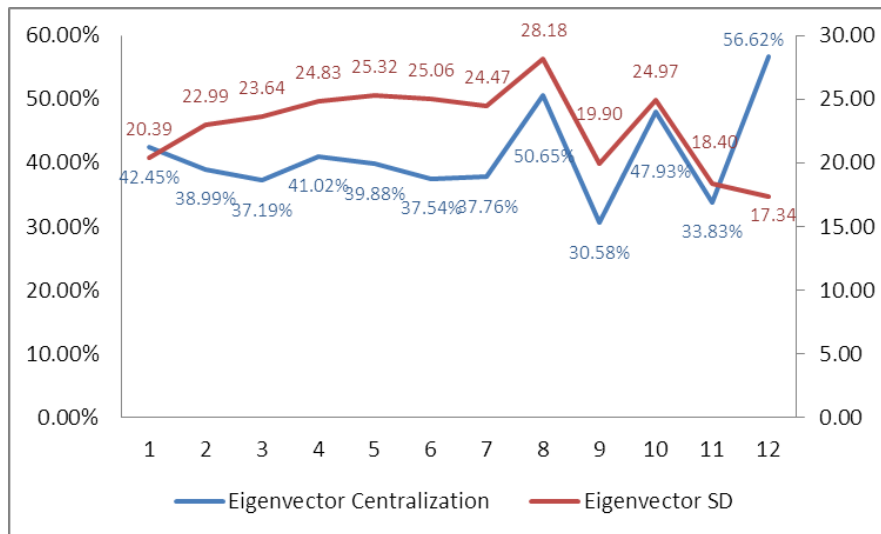
Figure 9.   Longitudinal scores of eigenvector centralization and its standard deviation.

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[96] Appendix 1.D provides a chart with topographical measures and centralization during the critical moments of the alliance. Appendix 1.E provides a visualization of the network's transformation over time.
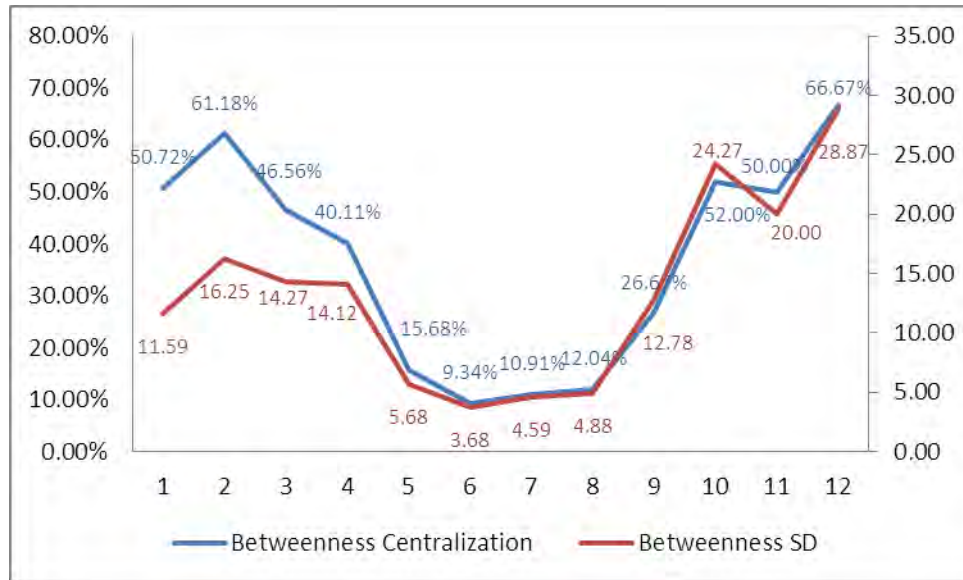
Figure 10. Longitudinal scores of betweenness centralization and its standard deviation in the El Nogal attack network.
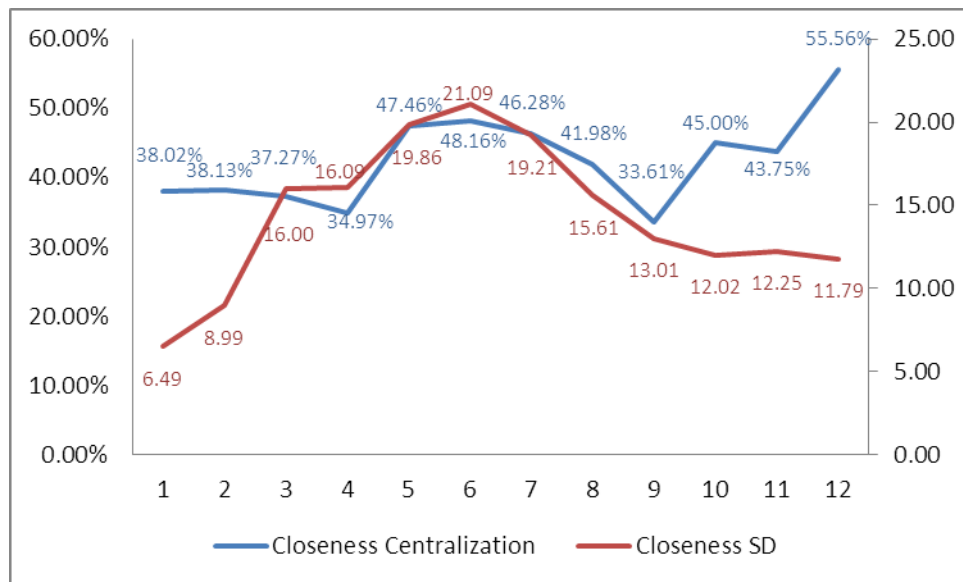
Figure 11. Longitudinal scores of closeness centralization and its standard deviation in the El Nogal attack network.

1. Social Network Change Detection

This section now turns to SNCD to identify significant changes in degree, betweenness, closeness, and eigenventor centralization.[97] The first three measures indicate that a significant event occurred at time 7 (Figures 12 and 13). These are visible by a reduction in betweenness and closeness centralization and an increase in degree centralization. It is possible that the death of one of the FARC's secretariat members could have affected the decision-making context of the organization, as well as initiatives formulation in the tactical and strategic ambiences importantly. The FARC had not registered the death of any one of its warlords in a recent time. The last event was the death of one of the FARC's cofounders, known as Luis Morantes, alias Jacobo Arenas, in August 10, 1990.[98]
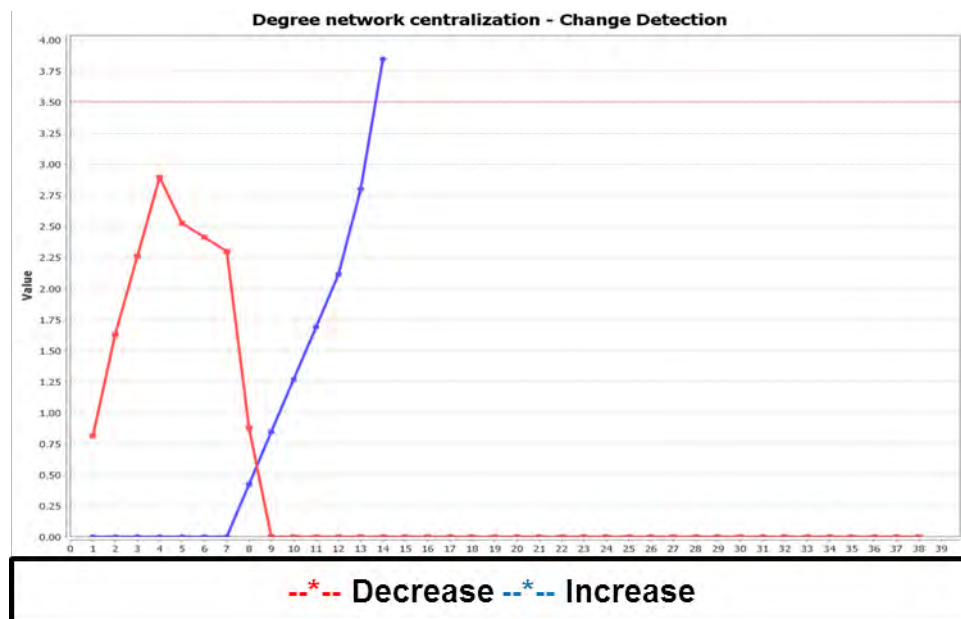
Figure 12.   SNCD reflects increasing in degree centralization at time seven (El Nogal attack network).

[97] McCulloh and Carley, *Social Network Change Detection*, 1–20.

[98] Insightcrime, "Las FARC 1964–2002: De Una Rebelión Desordenada a Una Máquina Militar" [The FARC 1964–2002: From a messed up rebellion to a military machine], http://es.insightcrime.org/investigaciones/farc-de-rebelion-desordenada-a-maquina-militar.
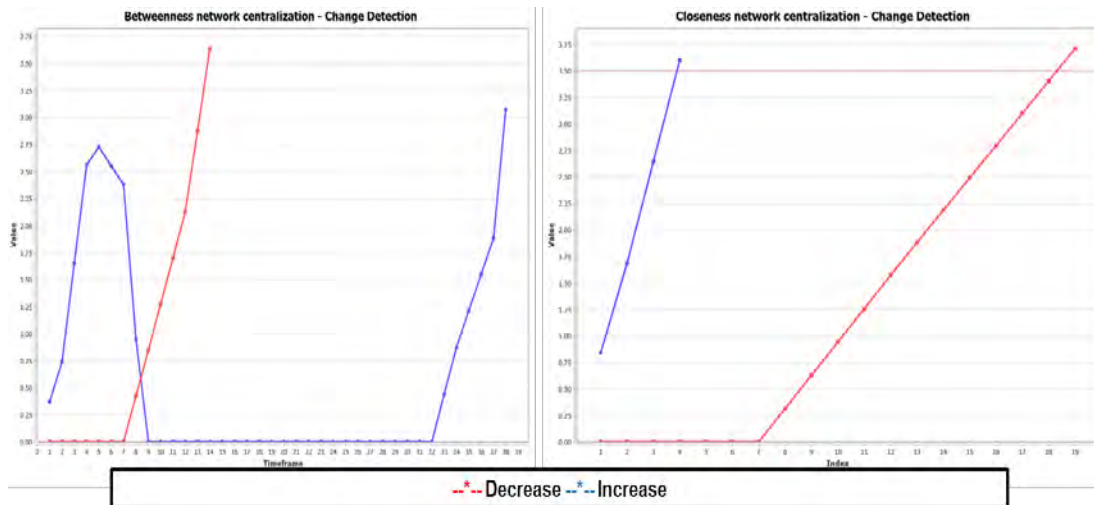
Figure 13. SNCD identifies decreasing in betweenness and closeness centralization at time seven (El Nogal attack network).

Eigenvector centralization reflects significant changes in the network as well. It increases during time 22 and decreases in time 28 (Figure 14). The increment figures grew from 37.76 to 50.65 percent. This variation could have its origin in the death from natural causes of the top leader of the organization known as Pedro Marín, alias Tirofijo, in March 2008. Eigenvector's decrease went to 30.58 percent in the time corresponding to August 2009 when authorities arrested FARC members requested in extradition by the United States justice.
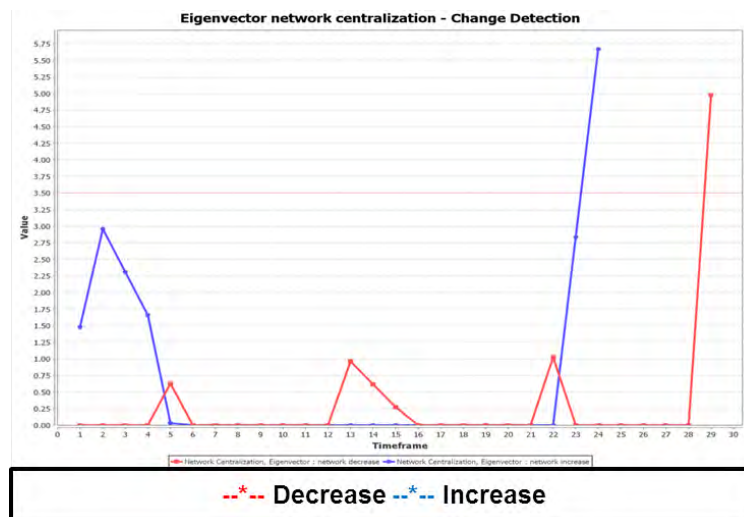
Figure 14. SNCD reflects increasing in eigenvector centralization at time 22 and decreasing at time 28 (El Nogal attack network).

E. CONSIDERATIONS FOR THE EL NOGAL CASE STUDY

This analysis identifies probable causes that motivated the terrorist attack against the El Nogal club. The FARC had a political motive to punish an "oligarchy symbol" of Colombia. In fact, this club is well-known because its members are part of the Colombian haute society who frequently visits these facilities. However, with regards to the context of this attack, one can argue that the FARC had prepared a series of terrorist events against a myriad of targets. Among the objectives were the military hospital, restaurants, and pubs in the northern zone of Bogotá.[99]

An interesting feature regarding this attack is the strategy to detach the FARC from any legal responsibility. Judicial investigations and the media revealed that the FARC decided to kill the criminals involved in this terrorist operation. During the terrorist attack, two members died, although the third member did not enter the premises and was arrested later and received a judicial sentence to serve 38 years in prison.

Once the group achieved its primary objective, the FARC might have thought to continue with their terrorist plans through their same members. This decision could be decisive in reducing their organizational capabilities, considering that authorities would have information about people and places that resulted in their arrests. One could suggest that when terrorist organizations pretend to perform extensive operations, a factor of success relies on the renewal of logistic and human resources. Nevertheless, there are two reasons for this network's success. First, the number of FARC members participating in various activities suggests that it had more direct control over the network's resources. Second, HDVSAP was able to control the network from a distance. He effectively communicated with the group by keeping his channels of

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[99] *El Espectador*, "Alias 'El Paisa' Presunto Responsable Del Atentado En Zona Rosa De Bogotá" [Alias 'El Paisa' responsible of the attack on Bogota's rose zone], http://www.elespectador.com/noticias/judicial/articulo-alias-el-paisa-presunto-responsable-del-atentado-zona-rosa-de-bogota.

communication open and through a variety of human sources. A segment of the network with a relevant role is the FARC's secretariat. The members of this hierarchical level are highly connected, and their ties contribute to the formation of a mesh type network, which allows it to make decisions by seeking consensus or unanimity. This behavior suggests that the organization at this level of command is very dense but highly sensitive to anything that happens to one of its members. Besides this, FARC members reside in different parts of the country, as well as outside of the country, which makes it highly resistant to the state actions. Moreover, the hierarchical structure allows it to access resources quickly, especially information moving through its structure.

The hierarchical level of the terrorist group is conscious of the violence deployed in its operations. One could argue that these decisions have served the organizational objectives. However, as rational actors, they must acknowledge the consequences derived from this type of action, like prosecutions and political detriment in their intentions for state control.[100] The level of violence could be a major factor why FARC members, like HDVSAP, do not belong to the upper level of command. The FARC might assess that his potential upgrade could bring forth adverse effects on their intentions as an armed movement particularly during the phase of political transitioning as an option to end the conflict in Colombia.[101]

The following chapter shows the development of the FARC's vision regarding criminal associations. The next case study occurs nine years after the El Nogal attack. It attempted to murder a former Minister of Interior in Bogotá. This event provides important insights about the transformation of the FARC concerning subcontracting criminal organizations to carry out relevant actions on their behalf.

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[100] Gordon H. McCormick and Frank Giordano, "Things Come Together: Symbolic Violence and Guerrilla Mobilization," *Third World Quarterly* 28, no. 2 (March 2007): 316.

[101] Gordon H. McCormick, Steven B. Horton, and Lauren A. Harrison, "Things Fall Apart: The Endgame Dynamics of Internal Wars," *Third World Quarterly* 28, no. 2 (March 2007): 323.

V.   FERNANDO LONDOÑO CASE STUDY

This chapter analyzes the terrorist attack against the former Minister of the Interior, Fernando Londoño, in May 2012. The chapter develops its content in three sections. First, it provides a detailed account of the events that occurred over a 24-month period, which are then condensed into seven critical periods. Table 11 summarizes the critical moments and particular periods on the timeline.[102]

Table 11.   Relationship between seven critical moments with every period on the timeline.

Critical moment	Timeline	Dates
1	1–2	April 2012–May 2012
2	3–5	June 2012–August 2012
3	6–15	September 2012–June 2013
4	16–17	July 2013–August 2013
5	18–21	September 2013–December 2013
6	22–23	January 2014–February 2014
7	24	March 2014 and beyond

The second section, as in the previous chapters, is an exploratory analysis of the network's members. It focuses on the behavior of actors in the overall network, particularly through their centrality measures and along their evolution over time. The analysis includes measures of degree, eigenvector, betweenness, and closeness centrality.

The third section describes the network's topography and its transformation over time. It utilizes ORA's change detection tool to identify drastic and statistically significant transformations in the network's level of centralization.

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[102] Details of the timeline are available in Appendix 3.B.

A. BACKGROUND AND CONTEXT OF THE TERRORIST ATTACK TO MURDER FERNANDO LONDOÑO

Fernando Londoño Hoyos was Minister of the Interior in Colombia. He served under the government of President Alvaro Uribe Velez during his first presidential period.[103] Once he left office, he directed a radio program at *Colmundo* station in Bogotá. According to the Protection Unit of the Ministry of the Interior, Londoño received threats from the FARC, which were confirmed with seized computer files belonging to the terrorist organization.[104] Some studies have sought to discern the reasons that led the FARC to attempt to murder Londoño. Some have pointed to the role he played in improving the country's security conditions and argued that the attack attempted to test the government's capacity to provide security at all its levels, ranging from the average citizen to the national level. Others have argued that the operation occurred while the Congress was considering a law project that gave tools to the government to conduct peace dialogues with guerrilla groups in Colombia.[105]

Sufficient information and motives exist to connect the FARC on the Londoño case. The intelligence activities and judicial investigations found that the FARC hired a criminal organization from the city of Cali to conduct the operation.[106] This group, known as the PEZ, subcontracted with two other gangs from Cali and Bogotá to carry out the attack. The criminal organization first formed an exploratory team to gather information about Londoño's routines and

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[103] Alvaro Uribe's first presidential term was from the year 2002 until 2006.

[104] Caracol Radio, "Gobierno Confirma Que Fernando Londoño Habría Recibido Amenazas" [Government confirms that Fernando Londoño had received threats], http://www.caracol.com.co/noticias/judiciales/gobierno-confirma-que-fernando-londono-habia-recibido-amenazas/20120516/nota/1688946.aspx.

[105] Jorge A. Restrepo, "¿Por Qué Contra Fernando Londoño Hoyos?" [Why against Fernando Londoño Hoyos?], *El Espectador*, http://www.elespectador.com/noticias/judicial/contra-fernando-londono-hoyos-articulo-346485.

[106] *Escrito De Acusación Caso Fernando Londoño* [Bill of indictment Londoño case], FGN-50000-F-25 *Escrito De Acusación Caso Fernando Londoño* [Bill of Indictment Londoño Case], Código único de la investigación [prosecution's unicode] 110016000028201201684, 2–62013).

daily routes. Most of the terrorist sub-network participated in the reconnaissance of routes and the collection of intelligence about his itinerary.

On May 15, 2012, the terrorist attack took place in Bogotá. Two members of the criminal organization from Cali (Colombia) placed an improvised explosive device (IED) on Fernando Londoño's vehicle. The type of device known as *lapa* (limpet in English) had not been used in the country before although it had been used extensively by international terrorist organizations such as ETA in Spain.[107] According to judicial investigations, HDVSAP was the terrorist in charge of financing this terrorist operation.[108] He paid 1,000 million Colombian pesos to the criminals carrying out the attack.[109] The criminal gang used this money to subcontract members of other organizations and obtain the necessary logistics for its execution.[110] Figure 15 shows members of the FARC and the criminal organizations involved in the terrorist attack, as well as in other crimes committed afterwards.[111] Red nodes represent members of the FARC, both the CMTF and the Sixth Front, while yellow nodes represent members of the criminal gangs.

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[107] Luis De la Calle and Ignacio Sánchez-Cuenca, "La Selección de Víctimas en ETA [ETA's selection of victims]," *Revista Española De Ciencia Política* 10 (2004): 53–79.

[108] This is the same terrorist that planned and executed the attack on El Nogal club (see Chapter IV).

[109] According to Colombian financing services the exchange rate for that period was nearly $1,771.60 pesos per dollar. These operations had an approximate cost of $ 564.46 U.S. dollars. This information was drawn from Banco de la República, *Serie Histórica - Tasa De Cambio Representativa Del Mercado (TRM)* [Historical series - representative market exchange rate].

[110] *El Tiempo*, "La Teófilo Pagó $ 1.000 Millones por Atentado a Londoño" [The Teófilo paid $1.000 million for attack on Londoño], http://www.eltiempo.com/archivo/documento/CMS-12626865.

[111] Appendix 3.A provides a list of open sources used in this chapter.
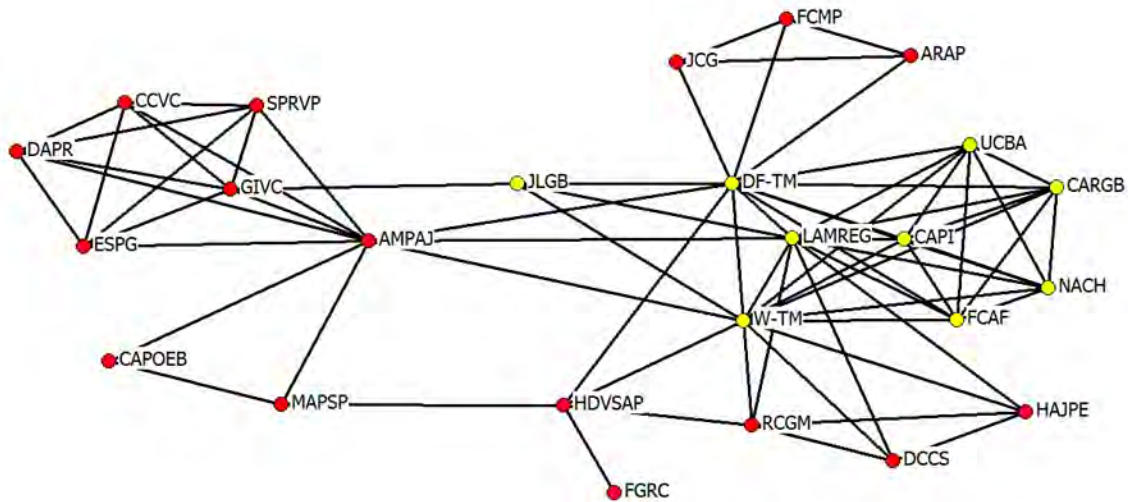
Figure 15.   Overall network of the Londoño case study.

The criminal-terrorist alliance in charge of conducting the attack against Fernando Londoño was a small group. It contained 25 people linked to the FARC and the subcontracted criminal groups. Sixty-four percent of its members belonged to the FARC (colored red in Figure 15) and 36 percent were members of the criminal organizations, the most prominent being the PEZ. In this case, the number of FARC members is larger than those belonging to the criminal groups. Nevertheless, the proportion of criminals is high, which suggests that the leaders of the criminal subgroup decided to form relationships with other criminals with the objective of accomplishing the task subcontracted by the terrorist organization.

The network is also diverse in terms of its organizational structure and the locations in which it operated. The FARC members belong to two different hierarchical levels. The first includes the mid-level commanders of the organization in charge of operational units such as the CMTF and the Sixth Front: HDVSAP, MP, and AMPAJ. The second corresponds to subordinated terrorists who perform tasks related to logistics, terrorism, and the group's security. This level includes the rest of the FARC members identified in this investigation. In terms of its areas of operations, the CMTF has direct influence

over Colombia southern departments of Huila and Caquetá, while the FARC's Sixth Front has presence in the western region of the country, particularly in the department of Cauca. One might think that geographic distance could present a disadvantage in the communications between the FARC's subgroups; however, this seems to not have been an issue in this case. In fact, HDVSAP was presumably 270 kilometers away from Bogotá, and the distance did not affect his capacity to guide a terrorist attack of such magnitude.

The area of operations of the primary criminal organization, PEZ, was centered in Cali city. Its relevant leader is DF-TM, who along with his brother W-TM, have a long criminal record in Colombia and Ecuador.[112] The PEZ conducts various activities related to theft, extortion, kidnapping, and murder. According to some press articles quoting one of the arrested terrorists, DF-TM and HDVSAP had friendship ties because of the presence of and activities carried out by DF-TM in the department of Caquetá. This suggests that the friendship started a long time ago; however, this investigation could not determine the length of that relationship based on the available data. On the other hand, the rest of the members of the criminal groups operate out of Cali and Bogotá.

HDVSAP, who is the head of the CMTF, planned and directed the terrorist attack against Fernando Londoño. He requested the authorization to carry out the plan using the criminal band PEZ, which the secretariat granted.[113] HDVSAP subcontracted DF-TM to carry out the attack. On April 2012 the PEZ traveled to Bogotá and contacted a second criminal organization led by a subject identified as UCBA. The TM brothers sought UCBA's help to gather information about the target's itineraries and mobilization routes. When the PEZ members returned to

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[112] *Semana*, "¿Y Qué Tal Este Delincuente?" [And, What about this criminal?], http://www.semana.com/nacion/articulo/y-que-este-delincuente/331454-3.

[113] It is worth mentioning that for this part of the investigation, the analysis focuses on the actions of the actors under the command of HDVSAP and related exclusively with operational units of the terrorist organization. Nevertheless, it could be argued that the secretariat's involvement was relevant; however, they remained in a position of observation on the operation's results. The secretariat's structure has remained stable since the year 2012 and they have not lost members of the highest hierarchical level during the last two years.

Cali, they approached a third organization from sector *El Vallado* in Cali. Their point of contact was CRGB, who was in charge of choosing members of his group, among them FCF, NACH, and an underage person known as CAPI, who attached the IED to the vehicle in which Minister Londoño was traveling.

In May 2012, the network traveled back to Bogotá one week before the event. After the attack, the members fled to different parts of Colombia. However, on August 2012, the National Police arrested five participants including UCBA, CRGB, NACH, FCF, and CAPI. Moreover, DF-TM and his associates sought help from HDVSAP. They requested protection from the FARC, but HDVSAP did not give them direct shelter and redirected the request to the FARC's Sixth Front commander, MP. He commanded AMPAJ to incorporate the TM brothers into the ranks of the FARC. This decision proved to be profitable for the Sixth Front's criminal intentions in the departments of Valle and Cauca.

The National Police conducted operations against members of the FARC's Sixth Front on June 2013. The police force arrested terrorists who were part of the group that was developing criminal actions to improve their financial status. Those criminal activities, including assaults and kidnappings, were planned and executed by DF-TM. Later, on August 2013, the Armed Forces hit the Sixth Front again. In a joint operation, AMPAJ and his second in command, CAPOEB, were killed. On December 2013, DF-TM died during a law enforcement operation along with other FARC members. This may have worried HDVSAP, which could explain why he strengthened the tie between his group, the CMTF, and the FARC's Sixth Front. His purpose could have been to exploit the criminal capabilities of the PEZ members embedded in the Sixth Front. Nevertheless, these ties dissolved after a police operation led to the arrest of W-TM, LAMREG and three FARC terrorists on February 2014 in the department of Huila, southern Colombia.

B. MEMBERS OF THE TERRORIST AND CRIMINAL NETWORK

This analysis now turns to an examination of the actors' centrality measures over time (see Table 12).[114] In terms of degree centrality, the TM brothers consistently maintained the greatest number of ties in the organization. This suggests they were able to maintain influence over the network's behavior. The transition of the TM brothers and their associate LAMREG to the terrorist group influenced the structural position of AMPAJ. He had the responsibility to secure the PEZ members who were fleeing from justice.

At the beginning of the alliance, DF-TM was the person with the highest eigenvector score. This makes sense given that he acted somewhat autonomously in planning and executing the attack, which suggests he was the organization's most important person. After the attack, the network dispersed and the eigenvector scores distributed evenly in most of the actors. One could analyze this distribution from the perspective of the conditioning of the criminal gang members to the new regime of the FARC's Sixth Front. In other words, the PEZ members felt they were on equal position with the terrorists because of the task they accomplished on the FARC's behalf. In a final stage of the alliance, W-TM, after the death of his brother DF-TM, had the highest eigenvector score because he shared his brother's ties with HDVSAP and other FARC members.

HDVSAP scored highest in terms of betweenness centrality. The combination of his role as commander of a mobile column and his access to the secretariat helps explain his brokerage power. The betweenness scores also suggest that the TM brothers possessed brokerage potential within the network. It appears that they took advantage of their knowledge and criminal experience to gain a position within the network in order to wield more influence. Another actor in position of brokerage was AMPAJ. He had the power to liaise between

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114 Appendix 3.C provides a list of the top ten actors with their centrality measures for every critical moment.

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the FARC and PEZ, which allowed him to promote criminal activities to benefit the financial conditions of the Sixth Front via assaults and kidnappings.[115]

Closeness centrality reveals an actor's potential access to resources. Over the course of the operation closeness scores had a homogenous distribution. Actors that registered similar scores belonged to the same clusters. In the first few periods of the network, particularly during the terrorist attack, members of the criminal groups continuously formed ties until all of them established a relationship. The TM brothers did not enter at the grassroots level of the terrorist group. Instead, they arrived in the upper echelon where they led operations and had ties with the commanders of the terrorist subgroup.

Table 12.   The top ten actors of the Londoño's overall network sorted by highest value.

Nº	Degree (norm.)	Closeness (norm.)	Betweenness (norm.)	Eigenvector (norm.)
1	DF-TM and W-TM (54.16)	DF-TM and W-TM (68.5)	AMPAJ (38.05)	W-TM (54.8)
2	LAMREG (50)	LAMREG (64.8)	DF-TM (32.5)	LAMREG (52.8)
3	AMPAJ (41.6)	AMPAJ (61.5)	W-TM (19.7)	DF-TM (51.2)
4	UCBA, CARGB, NACH, FCAF, and CAPI (29.16)	JLGB (51.06)	LAMREG (14.5)	UCBA, CARGB, NACH, FCAF, and CAPI (40.9)
5	GIVC (25)	HDVSAP (50)	HDVSAP (11.4)	AMPAJ (26.5)
6	HDVSAP, RCGM, CCVC, SPRVP, DAPR, and ESPG (20.8)	UCBA, CARGB, NACH, FCAF, and CAPI (48.9)	JLGB (2.8)	JLGB (21.4)
7	JLGB, DCCS, and HAJPE (16.6)	RCGM (46.15)	MAPSP (2.19)	RCGM (20.5)
8	MAPSP, JCG, FCMP, and ARAP (12.5)	DCCS and HAJPE (43.6)	GIVC (1.6)	DCCS and HAJPE (18.6)
9	CAPOEB (8.3)	GIVC, MAPSP, JCG, FCMP, and ARAP (42.8)	RCGM (1.14)	HDVSAP (17.1)
10	FGRC (4.16)	CCVC, SPRVP, DAPR, and ESPG (42.10)	--	GIVC (9.8)

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[115] *El Pais*, "Las Farc Asaltaron Carro De Valores en La Vía Santander de Quilichao-Cali" [The FARC Assaulted a Values Transportation Vehicle on the Way between Santander de Quilichao and Cali], http://www.elpais.com.co/elpais/judicial/noticias/dos-policias-heridos-dejo-ataque-carro-valores-panamericana.

C.   TOPOGRAPHICAL DIMENSIONS OF THE OVERALL NETWORK

The overall network tends to lie in the cosmopolitan dimension of network topography (see Table 13). The network's density is 0.24, which suggests that the network is relatively sparse and that actors did not form as many ties as they could have. The network's average degree is 5.84 and its clustering coefficient is 0.62. One could infer from the small-world quotient of 2.56 that network resources reached actors rapidly; it could also explain the fact that actors received innovative ideas with less resistance, assimilating changes quickly because of the influence of exogenous factors.

The network also tends to be heterarchical; however, its closeness centralization score suggests that it is moderately so. This measure, which was 45.17 percent, indicates that a small set of actors had greater access than others to information and resources within the network, and indeed the previous section identified the TM brothers as the actors with the highest closeness centrality scores. This potential accessibility was important to them in every critical moment during the length of the alliance (see Table 11). When one compares these scores with those of the Isaias Duarte murder network, 39.34 percent, and the El Nogal attack network, 38.02 percent, one could argue that closeness centralization and centrality are significant indicators of overall network behavior.

The other centralization measures are lower. For example, degree centralization equals 32.43 percent, which suggests that there was not a single actor in position of influencing the overall activity of the network. Similarly, betweenness centralization (34.46 percent) indicates that brokerage potential was widely distributed among actors. It is lower than the other two networks (Isaias Duarte 49.0 percent; El Nogal 50.72 percent), which may indicate the FARC evolved in their method of subcontracting with criminal gangs. It may have concluded that it was more important to have access to information than trying to control the flow of resources. Finally, eigenvector centralization, 42.17 percent, indicates that there was a relatively high proportion of actors connected to central others, particularly between members of the Sixth Front and the PEZ.

Table 13.   Summary of the Londoño attack overall network's centralization.

CENTRALIZATION MEASURES	SCORES
Degree centralization	32.43%
Betweenness centralization	34.46%
Eigenvector centralization	42.17%
Closeness centralization	45.17%

Standard deviation is another measure of centralization and indicates that it scored lowest in terms of degree and closeness centrality, suggesting that most members of the network had scores close to the mean. These scores suggest that a potential power to access resources and actors was possible for a small set of members like the TM brothers, LAMERG, AMPAJ, and HDVSAP. Table 14 summarizes the standard deviation scores.

Table 14.   Set of alternative measures regarding the network's standard deviation.

STANDARD DEVIATION	SCORES
Degree standard deviation	3.158
Betweenness standard deviation	10.284
Eigenvector standard deviation	17.012
Closeness standard deviation	9.65

D.   NETWORK'S EVOLUTION OVER TIME: A LONGITUDINAL ANALYSIS

The network had a life span of 23 months. The planning process of the terrorist attack against Londoño began in April 2012, and the security agencies carried out the last arrests in February 2014. According to the network timeline, each period corresponds to one month, which facilitates analysis regarding its evolution and the identification of drastic changes in its structure. The evolution of the network occurred in seven critical moments that influenced the behavior of

the actors. These critical moments correspond to law enforcement operations that caused the exit or entry of members to the organization.

During the first period of the network, it contained 11 actors who planned and conducted the attack. DF-TM, who had direct contact with HDVSAP and was the overall decision maker, was in charge of imparting responsibilities for each member of the alliance in Bogotá. One might argue that this operation did not have extreme compartmentalization settings among the criminals. In fact, the closeness centralization of 37.65 percent suggests that members had similar access to resources and other members of the network. The mesh-type shape of the organization suggests this subgroup was highly connected. Figures 16–19 identify the variation of centralization regarding the standard deviation of each critical moment.[116]

Once the group conducted the terrorist attack, it began the transition of criminals to the FARC's ranks. Between the times 3 and 15 (June 2012 to June 2013) one can observe increasing relationships with new actors who belong to the FARC's Sixth Front. The network grew from 11 actors to 25 actors before declining to 20 after the arrest of 5 members from the criminal gangs. In the period when the network had 25 actors it registered an average degree of 5.8. Between the times 6 and 15 (September 2012 to June 2013) the network had 20 actors and its average degree decreased to 4.8. This decrease could suggest that the network did not replace lost ties, which may have rendered it vulnerable. The clustering coefficient dropped from 0.85 to 0.58 between the first period and time 15 (April 2012 to June 2013), indicating that over a year after the attack, ties within the network stabilized. This might indicate that actors gave more effort to strengthen trust among them rather than forming new relationships.

Between times 16 and 22 (July 2013 to January 2014), the police conducted operations against the network. One law enforcement operation in

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[116] Appendix 3.D provides a chart with topographical measures and centralization in every critical moment. Likewise, Appendix 3.E provides a visualization of the network's transformation over time.

August 2013 led to the killing of AMPAJ and his second in command, CAPOEB. This strike removed a terrorist with high betweenness centrality. This potential power of brokerage allowed him to earn a relevant position in the FARC because of the criminal activities he was carrying out along with the TM brothers. Likewise, on December 2013 DF-TM was killed during a police operation with terrorists from the FARC's Sixth Front and the CMTF. The Colombian authorities had focused their efforts on localizing and arresting this individual not only for his involvement in the terrorist attack against Londoño, but also for his participation in the kidnapping of two police agents.[117]

The alliance between the PEZ and the FARC ended because of the arrest of W-TM and LAMREG on February 2014. According to press articles, the death of AMPAJ and DF-TM concerned HDVSAP.[118] This warlord had ordered his subordinates to strengthen the cooperation between the CMTF and the Sixth Front. Therefore, he exploited the criminal capabilities of W-TM and his associate LAMREG. These criminals were arrested with members of the FARC when they were moving weapons between the departments of Cauca and Huila. At this moment the network dropped to nine members, which increased the clustering coefficient, but reduced its average degree to 3.5. These measures suggest that the network increased its connectivity, or even after the removal of these actors, the network was still relatively cohesive.

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[117] *Noticias Caracol*, "Primeras Imágenes de La Liberación de Dos Policías Secuestrados por FARC" [First images of two policemen released who were kidnapped by the FARC], http://www.noticiascaracol.com/nacion/primeras-imagenes-de-la-liberacion-de-dos-policias-secuestrados-por-farc.

[118] José G. Pérez, "El Fin de La Alianza de Las Farc con El 'Parche De Zuley'" [The end of the alliance of the FARC with the 'el *Parche De Zuley*'], *El Tiempo*, http://www.eltiempo.com/justicia/alianza-de-las-farc-con-el-parche-de-zuley-llego-a-su-fin_13916279-4.
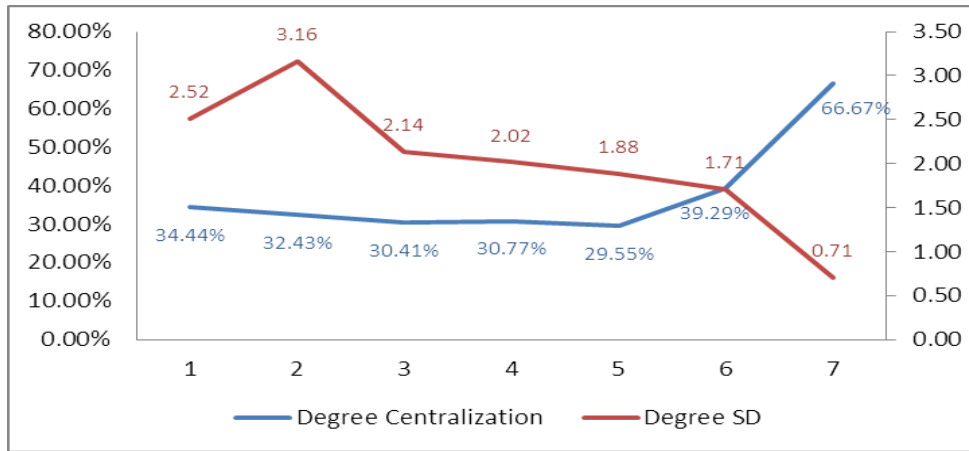
Figure 16.   Longitudinal scores of degree centralization and standard deviation in the Londoño attack network.
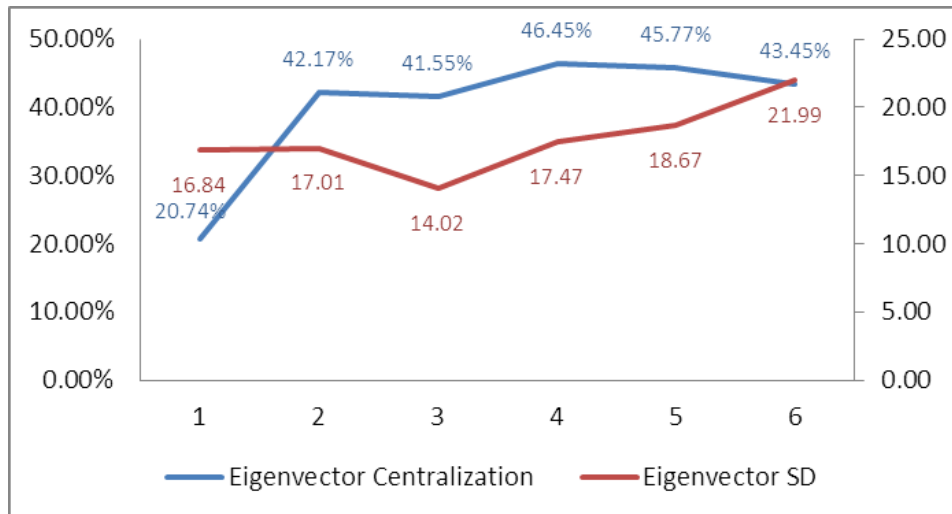
Figure 17.   Longitudinal scores of eigenvector centralization and standard deviation in the Londoño attack network.
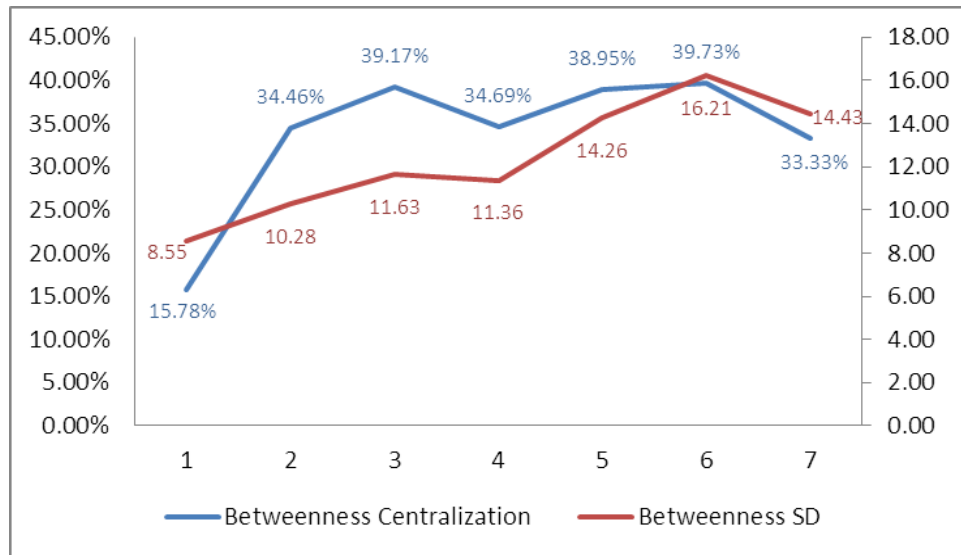
Figure 18. Longitudinal scores of betweenness centralization and standard deviation in the Londoño attack network.
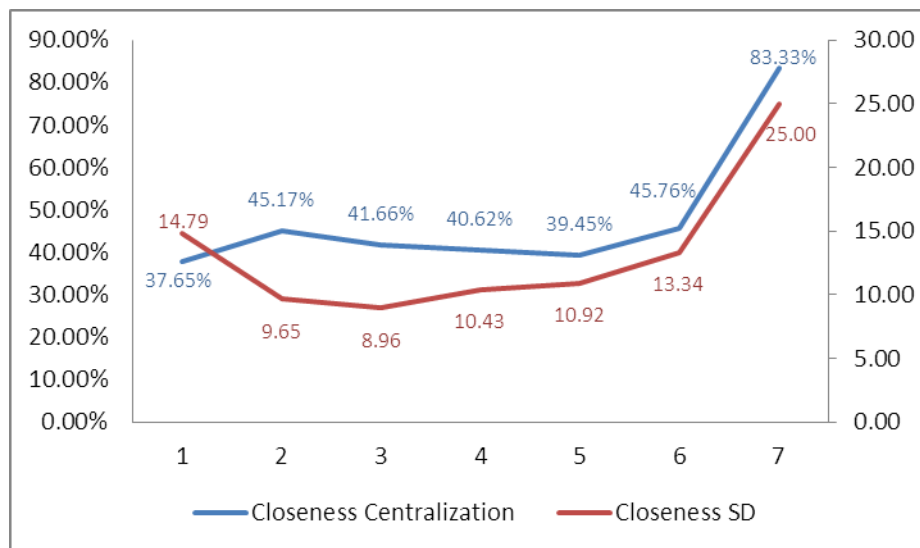
Figure 19.   Longitudinal scores of closeness centralization and standard deviation in the Londoño attack network.

1.   Social Network Change Detection

SNCD identifies significant changes in all four measures of centralization. The first occurred during the times 5 and 6 (August–September 2012) where there were significant decreases in degree and closeness centralization. The

arrest of the first members responsible for the execution of the terrorist attack could explain this decrease. Degree centralization varies from 32.43 percent to 30.41 percent. Decentralization of the criminal subgroup could constitute a crisis in which actors seek to base their relationships on trust.[119] On the other hand, closeness centralization decreases from 45.17 percent to 41.66 percent, and its standard deviation went from 9.65 to 8.96. The transformation of the network in time 6 does not allow this analysis to identify an actor with larger capabilities to contain potential power to access resources and actors quickly in the network. The formation of ties under these circumstances could reveal that factors like prestige are necessary to build trust. Likewise, criminal actors' experiences and culture could have been assessed by the FARC, in order to identify common features that would help them to strengthen ties easier.[120] Figures 20 and 21 show the cumulative sum control chart detecting changes in four measures of centralization.
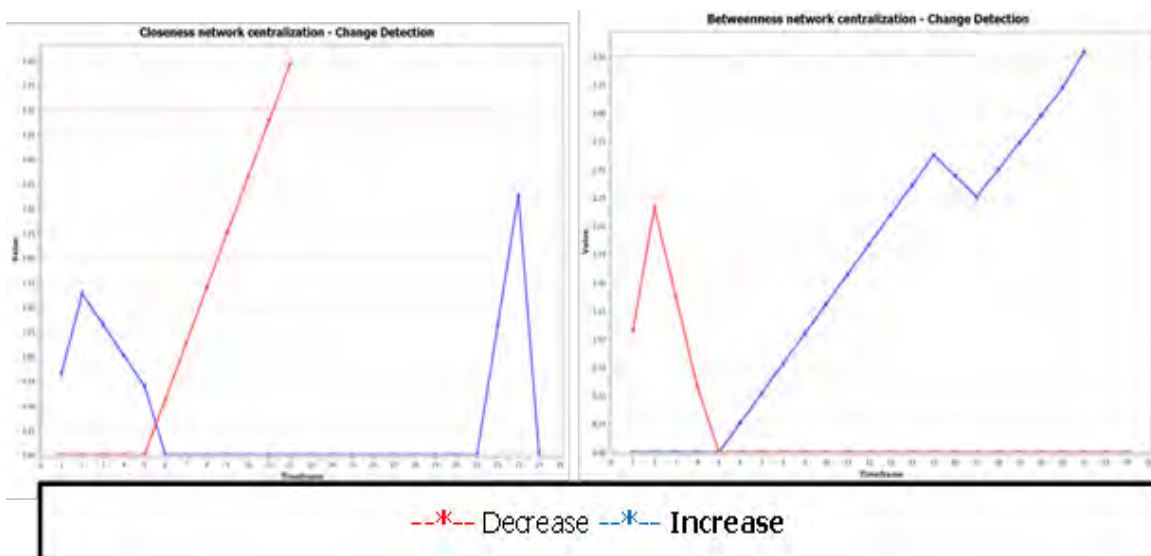
Figure 20.   SNCD reflects changes in closeness and betweenness centralization.

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[119] McCarthy, Hagan, and Cohen, "Uncertainty, Cooperation, and Crime: Understanding the Decision to Co-Offend," 174.

[120] Lin, *Social Capital: A Theory of Social Structure and Action*, 38.
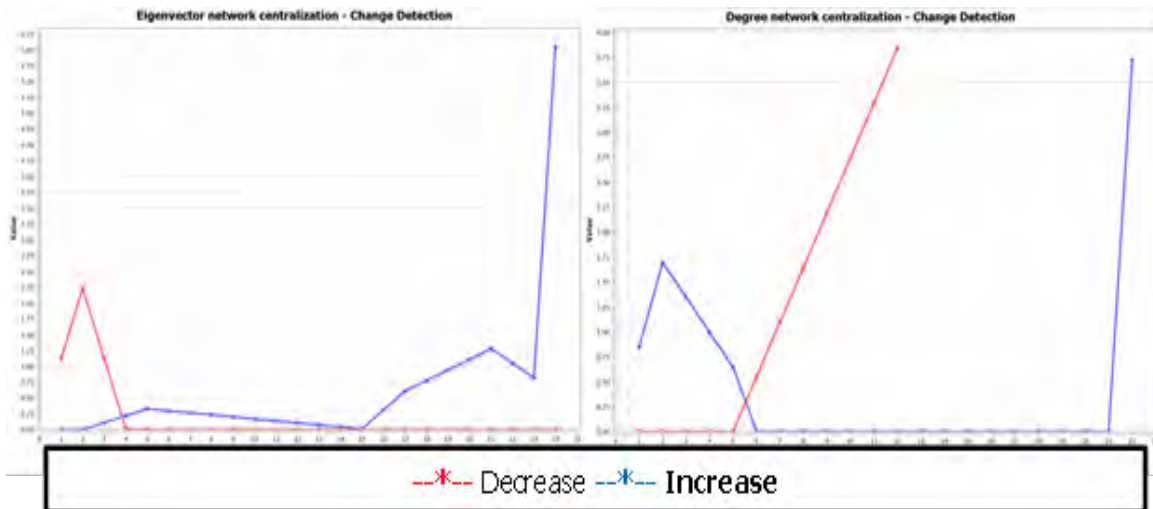
Figure 21.   SNCD illustrate transformation in eigenvector and degree centralization.

During the same periods, times 5 and 6, SNCD detects a statistically significant increase in betweenness centralization. It increases from 34.46 percent to 39.17 percent, and its standard deviation increases from 10.28 to 11.63. These scores contribute to understanding the FARC's role in the context of protectors of the PEZ members. At the moment of the criminal's transition into the FARC, the terrorist group protected the TM brothers and LAMREG until their role upgraded to belong formally to the FARC. As a protector, AMPAJ is the liaison between the FARC and the criminal organizations. One could argue that his position of brokerage allowed him to propose to his superiors that they recruit these criminals as new FARC members. Although this investigation does not have data regarding these orders, it is possible that the FARC's secretariat was involved in this decision.

There are other periods registering significant changes in eigenvector and degree centralization. Figure 22 indicates a significant change in eigenvector centralization occurred between periods 15 and 16. These periods are the prelude of law enforcement actions against the Sixth Front. However, these operations against the FARC could have opened a wider range of action for the TM brothers who took advantage of these strikes to approach FARC leaders and

renew the alliance with HDVSAP. SNCD of degree centralization indicates that significant changes occurred during times 21 and 22 (December 2013 and January 2014) suggesting that a small set of actors may have increased their ties; this appears to be the case with W-TM and LAMREG who would later be direct heirs of the alliance built by DF-TM.[121]

E.   CONSIDERATIONS FOR THE ATTACK AGAINST FERNANDO LONDOÑO

The exploratory and longitudinal analysis of this dark network leads to interesting findings regarding the security and efficiency tradeoff. The FARC subcontracted a criminal group to carry out the attack and obtained benefits for this decision, such as increasing their security in terms of legal and physical protection. One could argue that the legal protection is the most valuable aspect for their interests. Law enforcement agencies and the attorney general's office encountered difficulties in gathering evidence and prosecuting the FARC as the masterminds for terrorist actions like the one described here. Likewise, the FARC avoided physical damage, which is another security perspective for their benefit. In this case, the FARC let the criminal organization plan and execute the operation, which reduced the risk of their members being arrested or killed during the operation.

The second relevant finding is that the FARC formed a highly efficient partnership with a criminal gang, which allowed it to detach itself from the details of the terrorist plan. Once the criminal group fulfilled its task, the FARC sought to make use of them in other activities. Nevertheless, it is possible that HDVSAP did not want to add the members of PEZ to his subgroup. Instead, he transferred that responsibility to another terrorist structure away from his area of operations, which could indicate that he knew that the authorities would seek to locate and arrest all members of the network. Hence, HDVSAP's personal option was to help his associates without endangering the security of his group.

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[121] Appendix 3.F depicts graphs visualizing these changes using ORA.

Also interesting was the behavior of the criminal actors when they entered into the FARC's ranks. One could argue that the objective of the criminal organization was to earn an extraordinary amount of money and a relevant label of prestige among their peers in the criminal world. Nevertheless, following the first operations of the National Police, their goals changed towards their survival as new members of the FARC. In this sense, individual skills and a criminal background were major assets to convince the FARC's Sixth Front members they were essential to the organization. Nevertheless, their criminal activities only attracted more attention and ultimately ended the lives of several terrorists, including members with broad experience within the FARC.

The transformation of this network is a sample of the evolution of the FARC's strategic vision regarding alliance formation with criminal gangs. However, an underlying factor of attention for this transformation rests on the group's financial capabilities to promote terrorist attacks. Drug trafficking remains the primary source of revenue. The FARC earns nearly $1,5 billion dollars from its drug operations, which is about 4.5 to 7.5 percent of Colombia's gross domestic product.[122] This financial capacity is the greatest attraction for criminal groups that seek alliances with the FARC in order to execute terrorist attacks on their behalf.[123]

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[122] Revista Dinero, "La Chequera de Las FARC" [The FARC's checkbook], http://www.dinero.com/edicion-impresa/pais/articulo/los-lavados-activos-farc/190928.

[123] Daniel Mejía and Daniel Rico, "La Microeconomía de La Producción y Tráfico De Cocaína en Colombia" [Microeconomics of cocaine production and trafficking in Colombia], *Documentos Centro de Estudios Sobre Desarrollo Económico,* July 2010.

VI.   CONCLUSIONS

The objective of this investigation was to shed light on the potential risk to Colombia's security from a segment of the FARC that rejects the current peace process. It examined three relatively recent case studies demonstrating the FARC's strategic use of alliances with criminal organizations, which continue to destabilize the country.[124] For the FARC, these alliances appear to provide several operational advantages in the post-conflict era, including plausible deniability in terrorist attacks. For the criminal organizations, these alliances bolster their financial resources and help them earn prestige among their peers in the criminal world.

The use of alliances at the end of conflicts is not a new phenomenon and has been seen in similar situations in the past, including at the end of conflicts in Nicaragua, Guatemala, and El Salvador. Nevertheless, this research is unique in that it utilizes both historical and social network analysis to examine empirically these alliance networks. Moreover, it identifies common characteristics that may help prevent or minimize further violence.

A.   ASSESSMENT OF THE HISTORICAL CONTEXT

The FARC have adapted their methods to conduct terrorist operations by learning to exploit their allies' capabilities. During past peace processes, the FARC continued to carry out its own operations in a relatively independent manner. For example, the FARC confronted the state head-on during the 1999–2002 peace process.[125] It appears to have transitioned to a policy of forming alliances with other organizations, one that allows members of the FARC

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124   *Semana*, "El Matrimonio Diabólico Entre Las FARC y Los Úsuga" [The diabolic marriage between the FARC and the Usugas], http://www.semana.com/nacion/articulo/el-matrimonio-diabolico-entre-las-farc-los-usuga/403466-3.

125   Román D. Ortiz, "Insurgent Strategies in the Post-Cold War: The Case of the Revolutionary Armed Forces of Colombia," *Studies in Conflict & Terrorism* 25, no. 2 (2002): 136–140.

to subcontract terrorist operations to individuals and groups operating under a "model of accountability." In other words, the criminal gangs are granted considerable freedom in planning and executing the operations, but at the same time, they (and not the FARC) are answerable for their actions.

The FARC's change in policy is based on several advantages of outsourcing terrorism. First, it can focus on its strategic goals by leaving the details of conducting criminal and terrorist operations to the groups to which it is outsourcing violence. Second, it can hide its real intentions and capabilities from the public, which allows it to select which actions to claim and advertise as a show of force. Third, it can deny its involvement in politically sensitive events that may produce backlash from the population. In addition to these advantages, it is important to understand the social structure of these alliances in order to fully understand their nature and to make thoughtful considerations.

B.   SOCIAL NETWORK ANALYSIS

1.   Topographical Dimensions

The three networks have several structural characteristics in common. One is their relatively small size. None of the networks consisted of more than 30 members, which is interesting given the size of the organizations involved. A likely factor limiting their sizes is the FARC's focus on maintaining plausible deniability and keeping the operations covert.

The other network topographical metrics used in this analysis also highlight some interesting patterns (see Table 15). For instance, they suggest that the groups tend to be in the cosmopolitan dimension in terms of cohesion, which suggests that tie formation was somewhat limited among actors in the networks. For example, both the El Nogal and the Londoño networks demonstrated relatively low levels of clustering as indicated by their clustering coefficient. On the other hand, the Isaias Duarte network had a larger clustering coefficient, indicating that one of its segments was highly connected. This would suggest that this particular network may not fit within the cosmopolitan dimension

of clustering. However, the small-world quotient and an abundance of weak ties within each network both suggest all three networks fall on the cosmopolitan side of the dimension.

The networks also appear to balance their position within the hierarchical and heterarchical dimension of network topography. The centralization scores across all four measures used throughout the previous chapters are all relatively balanced (at least mathematically) between 0.0 and 0.1. In other words, there was not a single actor within each network who had the capacity to control or influence the networks altogether. This balance may help explain why the networks were able to conduct their criminal and terrorist operations efficiently. For the Isaias Duarte and the El Nogal networks, their highest centralization measure was betweenness, suggesting that they had actors who were mainly FARC members, with the potential to serve as brokers between clustered segments. On the other hand, the Londoño network was largely centralized in terms of the closeness centralization, which implies that some actors could access other actors and resources quickly. Table 15 summarizes the overall features of networks' topographical dimensions.

Table 15.   Summary of networks' topographical dimensions.

Features	Isaías Duarte	El Nogal Club	Fernando Londoño
Size	21	27	25
Average Degree	+/- Dense	Sparse	Sparse
Clustering coefficient	Medium–High	Low–Medium	Low–Medium
Small-world quotient	Low–Medium	Low–Medium	Low–Medium
Ties	Strong ties	Weak ties	Weak ties
Centralization	Low–Medium	Low–Medium	Low–Medium
Standard deviation	Low–Medium	Low–Medium	Low–Medium

2. Measures of Centrality

Overall, the FARC members, specifically formal leadership, were more central and more influential than the criminal group members in all three networks, which makes sense given these were FARC-driven operations. That being said, two other possible explanations may exist. The first one is based on the FARC's overall network structure and the second on the group's operational coverage of large portions of Colombia. In terms of the former, the FARC's network structure allows the leadership to be aware of the evolution of the terrorists' plans, and if necessary, to intervene in the decision-making process despite their attempts to remain hidden in the face of counterterrorism efforts. In terms of the latter, the FARC maintains significant presence in a wide range of areas across the country.

The overall centrality results suggest that the FARC sought to sustain control in their operations and that the commanding staff was completely aware of every operational plan. In fact, the FARC members consistently had the largest amount of ties, including permanent access to the highest hierarchical levels of the organization. Regarding the FARC's secretariat, it is important to highlight that they are located in remote and almost inaccessible areas, but they can still manage to gain access to their networks and their resources at any time. Similarly, the front's leaders had the ability to command these operations from a distance. Most of these terrorists have the potential power to serve as brokers and use means to access information and resources quickly.

3. Longitudinal Analysis

Both endogenous and exogenous factors influenced the transformation of the networks over time.[126] In terms of endogenous factors, the FARC eliminated several criminal actors across the three networks. In the El Nogal attack, the FARC killed the perpetrators and appear to have only cared about accomplishing

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[126] Ian McCulloh and Kathleen M. Carley, *Detecting Change in Longitudinal Social Networks* (New York: Military Academy West Point Network Science Center, 2011).

its goal of a successful operation. In the Duarte and El Nogal cases, the criminal gangs also appeared to be expendable in the sense that the FARC did not see additional value in them after the events. The Londoño case shows the effect of additional endogenous factors, namely the acceptance of criminal members into their formal ranks.

In terms of exogenous factors, the most relevant are the effects caused by law enforcement operations. These actions had a significant effect on the structural composition of the organizations. They appear to have caused the networks to become more cohesive and centralized, suggesting that the state's operations were able to reach members in the periphery of the networks, but not enough to harm the core of these organizations.[127] That being said, the application of SNCD showed law enforcement operations had particularly noticeable effects on both betweenness and closeness centralization.[128]

C.   CONSIDERATIONS FOR THE AUTHORITIES

The characteristics of these networks, based on both historical and social network analyses, present a set of possible strategic implications to counter the FARC-criminal alliance phenomenon. According to Roberts and Everton, strategic options for countering dark networks can be divided into two broad categories: kinetic and non-kinetic.[129] Kinetic strategies refer to the targeting of persons, groups, and organizations through aggressive means in order to neutralize, capture, or eliminate them. The non-kinetic approach, on the other hand, involves less aggressive ways and its purpose is to secure the population's safety and support and undermine the enemy's influence and control. It is indirect and seeks to affect terrorists or criminal groups physically and psychologically.

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[127]   Kathryn Oliver et al., "Covert Network Data: A Typology of Effects, Processes, Practices and Structures" (paper presented at *Sunbelt XXXIV,* the Annual Meeting of the International Network for Social Network Analysis in St. Pete Beach, FL*,* February 18–23, 2014).

[128]   McCulloh and Carley, *Social Network Change Detection*, 1–20.

[129]   Nancy Roberts and Sean F. Everton, "Strategies for Combating Dark Networks," *Journal of Social Structure* 12, no. 2 (2011): 5.

The first strategic implication has to do with the FARC's leadership at the front level. Decision makers should focus on increasing the armed forces' operations against the FARC fronts' leaders, particularly those terrorists who reject the peace agreements. These actors appear to be critical in the formation of alliances because they are scouting new criminal fields to improve their financial status. In addition, they will structure new organizations with criminal and terrorist capabilities in order to test the state in its mission to provide security, ranging from the citizen to national security. A possible strategy is to increase and sustain the state's presence in geographical areas of criminal dominion where there has been a security gap historically. The longitudinal analysis of this research suggests that the immediate reaction of criminals after conducting an operation is to seek shelter in what they call their sanctuaries. Therefore, the presence of the police and military forces in these zones can motivate the dispersion of criminals and enforce their displacement. This action could have similar effects to network's fragmentation when one seeks to isolate actors. In this sense, the terrorists might find limitations to elaborate new plans, and this could bring about their exposure and ultimately lead to their location and neutralization.

A second strategic implication derived from this analysis has to do with the continued importance of the FARC secretariat. The terrorist organization is highly sensitive to anything that happens to one of its members at this level. Therefore, it is important to assess the current strategies to neutralize these actors, including new perspectives of action, such as the prosecution of their personal finances and their criminal alliances. This research has highlighted their accessibility to the details of operations conducted by criminal organizations on their behalf. Therefore, it is necessary to deploy further capabilities in psychological and deception operations to disturb their judgment during their decision-making process. The fact that most leaders are separated from daily operations (as in the previous examples) and have to make decisions from faraway geographic locations lends itself to these types of operations.

A third strategy derived from this analysis could focus on the state's capabilities for preventing the formation of new alliances with criminal groups. One approach would be to motivate and accelerate the demobilization process of combatants before the peace process concludes. This would help improve understanding of the FARC's structural composition, which would help predict potential risks to the security. A complementary approach would be to pay more attention to vulnerable population. The state must create plans to deploy its agencies to identify geographical areas in risk. It should prioritize the assessment of the younger population that could follow the line of criminal inheritance that in the near future allows them to become the new warlords in Colombia.[130]

A final strategy could focus on discouraging criminal organizations from serving the FARC's purposes. It is, in fact, a gigantic task for Colombian authorities to identify criminal groups willing to associate with terrorists. Consequently, the authorities could take at least two approaches to deal with this dilemma. The first one is for the authorities to work on developing a cohesive narrative toward populations affected with high-crime rates. This approach could lead to better relationships with these populations who could provide the authorities with important information about criminal networks and their potential affections toward the FARC. A second approach would be to develop psychological campaigns across criminal organizations' territories. The goal of these campaigns would be to create distrust between the FARC and various criminal organizations.

The historical context and social network analyses used here have shed light on the type of networks that create risks to Colombia's security in the near future. It is clear that criminality in the country has already shifted to a more sophisticated context in which terrorist or criminal ideologies couple with the objective of confronting the state. The FARC's method of subcontracting out

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130 Carlos Andres Prieto, "Las BACRIM y El Crimen Organizado en Colombia" [The BACRIM and organized crime in Colombia], *Friedrich Ebert Stiftung FES Policy Paper* 47 (March 2013), 13.

violence is the newest sign demonstrating this shift that will challenge the state in the near future and its goal to provide security throughout the country. Consequently, this research provided the first step in analyzing a phenomenon that must be fully understood in order for the state to develop practical alternatives to develop and maintain peace in a post-conflict Colombia.

APPENDIX 1.   ISAÍAS DUARTE CASE STUDY

A.   LIST OF OPEN SOURCES

Source	Title (in original language)	Date	Internet link
El Tiempo	Sicario salió 72 horas de cárcel para matar a monseñor Duarte [Murderer left jail 72 hours to kill Monsignor Duarte]	February 1, 2002	http://www.eltiempo.com/archivo/documento/MAM-5160703
La Vanguardia	Detienen al jefe de una banda de sicarios por el asesinato del arzobispo de Cali [Arrested chief of a killers' gang charged for the killing of Cali's Archbishop]	March 26, 2002	http://www.lavanguardia.com/internacional/20020326/51262752148/detienen-al-jefe-de-una-banda-de-sicarios-por-el-asesinato-del-arzobispo-de-cali.html#ixzz38KjFFXDm
El Tiempo	Asesinado presunto sicario de Duarte C. [Killed hitman presumed assassin of Duarte]	May 31, 2002	http://www.eltiempo.com/archivo/documento-2013/MAM-1309855
El Tiempo	El Asesinato de monseñor [The killing of monsignor]	June 11, 2002	http://www.eltiempo.com/archivo/documento-2013/MAM-1369853
El Tiempo	Exterminio en caso Duarte C. [Extermination in Duarte C.'s case]	October 11, 2002	http://www.eltiempo.com/archivo/documento/MAM-1375247
Colombia.com	Capturado "eslabón" en crimen de monseñor Duarte Cancino [Arrested "link" in crime of Monsignor Duarte]	November 6, 2002	http://www.colombia.com/noticias/autonoticias/2002/DetalleNoticia16401.asp
El Tiempo	Murió de un infarto cofundador de FARC [FARC's cofounder died from a heart attack]	December 13, 2003	http://www.eltiempo.com/archivo/documento/MAM-1049019
El País	72 años de cárcel para asesinos de Arzobispo [72 years of prison for killers of Archbishop]	January 19, 2005	http://historico.elpais.com.co/paisonline/notas/Enero192005/D419N1.html

List of Open Sources (continued)

Source	Title (in original language)	Date	Internet link
El tiempo	Absuelven a uno de los acusados por la muerte de monseñor isaías duarte cancino [absolved one of the accused for the death of monsignor]	October 26, 2006	Http://www.eltiempo.com/archivo/documento/cms-3300998
El tiempo	Dictan aseguramiento contra 10 presuntos miembros de la banda 'el grande' o 'el alto' [ordered security measure against 10 members of gang el grande]	December 1, 2008	Http://www.eltiempo.com/archivo/documento/cms-4698920
General attorney office	Fallo condenatorio contra miembros de la banda 'el grande' [conviction against members of el grande]	December 4, 2009	Http://www.fiscalia.gov.co/colombia/noticias/fallo-condenatorio-contra-miembros-de-la-banda-el-grande/
El país	Asesinan a hombre que fue investigado por la muerte de isaías duarte cancino [a man killed who was investigated for the death of isaías duarte]	May 30, 2011	Http://www.elpais.com.co/elpais/judicial/asesinado-hombre-implicado-en-muerte-arzobispo-cali-isaias-duarte-cancino
Colombia reports	Mafioso farc boss 'mincho' killed in bombing raid	October 20, 2011	Http://colombiareports.co/mafioso-farc-leader-mincho-killed-in-bombing-raid/
El tiempo	Se cae fallo contra las farc por crimen de monseñor duarte [conviction of the farc fails regarding crime on monsignor]	March 27, 2013	Http://www.eltiempo.com/archivo/documento/cms-12713324
El colombiano	Piden incluir testimonio en caso de monseñor isaías duarte cancino [they request to include testimony in duarte's case]	March 31, 2013	Http://m.elcolombiano.com/article/134691
Semana	Caso de monseñor duarte, ¡qué fallo! [monsignor duarte case, what a failure!]	April 6, 2013	Http://www.semana.com/nacion/articulo/caso-monsenor-duarte-que-fallo/339025-3

B. TIMELINE

Date	Type of event	Description	Timeframe
3/16/2002	Assassination	Archbishop Isaías Duarte-Cancino killed in Cali city by two murderers	1
3/26/2002	Military operation	Criminal contact 1 and 2 were arrested by military units. They were allegedly participating as contacts of the Archbishop Duarte's murderers. They were released later.	1
4/10/2002	Law enforcement operation	National Police arrested Hitman 1 and 2. They were accused of killing the Archbishop.	2
5/30/2002	Killing	Hitman 1 was murdered inside a penitentiary in Cali city.	2
6/8/2002	Law enforcement operation	National Police arrested JFJ-FCCO, allegedly a FARC contact with the murderers	2
7/2/2002	Killing	Criminal contact 1 was killed. He was captured by military units allegedly for being a contact of the murderers	3
10/9/2002	Killing	Criminal contact 2 was killed. He was captured by military units allegedly for being a contact of the murderers	4
12/13/2003	Death	Secretariat 3 dies from natural causes. This former FARC leader was allegedly one of the terrorists who order the assassination of the archbishop	8
1/18/2005	Judicial Sentence	JFJ-FCCO is found guilty for the murder of Archbishop Duarte.	13
10/1/2006	Judicial Sentence	JFJ-FCCO is released after a Criminal Court examined the testimony related to his participation in the crime.	20
11/27/2008	Law enforcement operation	Members of the criminal organization El Grande were arrested in Cali City for their involvement in different crimes. Among the arrested is JFJ-FCCO	28
12/4/2009	Judicial Sentence	Members of the criminal organization El Grande were sentenced to prison for their involvement in different crimes. Among the convicted is JFJ-FCCO	32
5/28/2011	Killing	JFJ-FCCO was murdered in rural area 30 kilometers southern Cali-Colombia	38
10/20/2011	Military operation	JNUV-FCCO was KIA during a military operation. This former FARC leader was allegedly one of the terrorists who order the assassination of the bishop	40
11/4/2011	Military operation	Secretariat 2 was KIA during a military operation. This former FARC leader was allegedly one of the terrorists who ordered the assassination of the bishop	40

C.   CENTRALITY MEASURES OVER TIME

TOP 10 X TIME							
Time 1–2 - Net. Size 11							
degree	score	eigenvector	score	Between.	score	closeness	score
PC-FCCO	7	PC-FCCO	69.832	PC-FCCO	60.00	PC-FCCO	85.00
Hitman 1	4	Secretariat 1	56.996	Criminal contact 1	11.85	Secretariat 4	65.00
Secretariat 1	4	Secretariat 3	56.996	Criminal contact 2	11.85	Secretariat 1	65.00
Secretariat 2	4	Secretariat 2	56.996	JNUV-FCCO	11.11	Secretariat 2	65.00
Secretariat 3	4	Secretariat 4	56.996	Hitman 1	8.15	Secretariat 3	65.00
Secretariat 4	4	criminal contact 1	24.272	JFJ-FCCO	2.96	criminal contact 1	65.00
criminal contact 1	3	criminal contact 2	24.272	Hitman 2	0.74	criminal contact 2	65.00
Hitman 2	3	JNUV-FCCO	18.527	Secretariat 1	0.00	Hitman 1	63.33
criminal contact 2	3	Hitman 1	17.17	Secretariat 2	0.00	JNUV-FCCO	58.33
JFJ-FCCO	2	Hitman 2	15.553	Secretariat 3	0.00	Hitman 2	56.67
Time 3 Net. Size 9							
degree	score	eigenvector	score	Between.	score	closeness	score
PC-FCCO	7	PC-FCCO	69.616	PC-FCCO	75	PC-FCCO	93.75
Secretariat 4	4	Secretariat 1	59.713	JNUV-FCCO	25	Secretariat 4	72.917
Secretariat 3	4	Secretariat 3	59.713	Criminal contact 2	0	Secretariat 2	72.917
Secretariat 1	4	Secretariat 2	59.713	Secretariat 3	0	Secretariat 1	72.917
Secretariat 2	4	Secretariat 4	59.71	Criminal contact 1	0	Secretariat 3	72.917
JNUV-FCCO	2	JNUV-FCCO	17.733	Secretariat 1	0	JNUV-FCCO	62.5
Criminal contact 2	1	criminal contact 1	16.711	JFJ-FCCO	0	Criminal contact 2	54.167
JFJ-FCCO	1	criminal contact 2	16.711	Secretariat 2	0	Criminal contact 1	54.167
Criminal contact 1	1	JFJ-FCCO	4.257	Secretariat 4	0	JFJ-FCCO	43.75

Centrality Measures over Time (continued)

Time 4 Net. Size 8							
degree	score	eigenvector	score	Between.	score	closeness	score
PC-FCCO	6	PC-FCCO	67.554	PC-FCCO	66.667	PC-FCCO	92.857
Secretariat 4	4	Secretariat 1	60.915	JNUV-FCCO	28.571	Secretariat 4	76.19
Secretariat 3	4	Secretariat 3	60.915	Secretariat 3	0	Secretariat 2	76.19
Secretariat 1	4	Secretariat 2	60.915	Criminal contact 2	0	Secretariat 1	76.19
Secretariat 2	4	Secretariat 4	60.915	Secretariat 1	0	Secretariat 3	76.19
JNUV-FCCO	2	JNUV-FCCO	17.476	JFJ-FCCO	0	JNUV-FCCO	64.286
Criminal contact 2	1	criminal contact 2	16.441	Secretariat 2	0	Criminal contact 2	54.762
JFJ-FCCO	1	JFJ-FCCO	4.253	Secretariat 4	0	JFJ-FCCO	45.238
Time 5–9 Net. Size 7							
degree	score	eigenvector	score	Between.	score	closeness	score
PC-FCCO	5	PC-FCCO	65.454	PC-FCCO	53.333	PC-FCCO	91.667
Secretariat 3	4	Secretariat 1	62.053	JNUV-FCCO	33.333	Secretariat 3	80.556
Secretariat 2	4	Secretariat 3	62.053	Secretariat 3	0	Secretariat 2	80.556
Secretariat 1	4	Secretariat 2	62.053	Secretariat 1	0	Secretariat 1	80.556
Secretariat 4	4	Secretariat 4	62.053	JFJ-FCCO	0	Secretariat 4	80.556
JNUV-FCCO	2	JNUV-FCCO	17.188	Secretariat 2	0	JNUV-FCCO	66.667
JFJ-FCCO	1	JFJ-FCCO	4.239	Secretariat 4	0	JFJ-FCCO	47.222

Centrality Measures over Time (continued)

Time 10–19 Net. Size 6

degree	score	eigenvector	score	Between.	score	closeness	score
PC-FCCO	4	PC-FCCO	74.138	PC-FCCO	60	PC-FCCO	90
Secretariat 1	3	Secretariat 1	67.613	JNUV-FCCO	40	Secretariat 1	76.667
Secretariat 2	3	Secretariat 2	67.613	Secretariat 1	0	Secretariat 2	76.667
Secretariat 4	3	Secretariat 4	67.613	JFJ-FCCO	0	Secretariat 4	76.667
JNUV-FCCO	2	JNUV-FCCO	26.73	Secretariat 2	0	JNUV-FCCO	70
JFJ-FCCO	1	JFJ-FCCO	8.632	Secretariat 4	0	JFJ-FCCO	50

Time 20–28 Net. Size 16

degree	score	eigenvector	score	Between.	score	closeness	score
JFJ-FCCO	11	JFJ-FCCO	44.248	JFJ-FCCO	47.857	JFJ-FCCO	83.333
El Grande 1	10	El Grande 3	43.816	JNUV-FCCO	41.905	El Grande 1	77.222
El Grande 2	10	El Grande 2	43.816	PC-FCCO	34.286	El Grande 2	77.222
El Grande 3	10	El Grande 5	43.816	El Grande 1	0.238	El Grande 3	77.222
El Grande 4	10	El Grande 1	43.816	El Grande 2	0.238	El Grande 4	77.222
El Grande 5	10	El Grande 4	43.816	El Grande 5	0.238	El Grande 5	77.222
El Grande 6	10	El Grande 7	43.816	El Grande 4	0.238	El Grande 6	77.222
El Grande 7	10	El Grande 6	43.816	El Grande 3	0.238	El Grande 7	77.222
El Grande 8	9	El Grande 9	40.422	El Grande 7	0.238	El Grande 8	73.889
El Grande 9	9	El Grande 8	40.422	El Grande 6	0.238	El Grande 9	73.889

Time 29–38 Net. Size 6

degree	score	eigenvector	score	Between.	score	closeness	score
PC-FCCO	4	PC-FCCO	74.138	PC-FCCO	60	PC-FCCO	90
Secretariat 1	3	Secretariat 1	67.613	JNUV-FCCO	40	Secretariat 1	76.667
Secretariat 2	3	Secretariat 2	67.613	Secretariat 1	0	Secretariat 2	76.667
Secretariat 4	3	Secretariat 4	67.613	JFJ-FCCO	0	Secretariat 4	76.667
JNUV-FCCO	2	JNUV-FCCO	26.73	Secretariat 2	0	JNUV-FCCO	70
JFJ-FCCO	1	JFJ-FCCO	8.632	Secretariat 4	0	JFJ-FCCO	50

Centrality Measures over Time (continued)

Time 39–40 Net. Size 5

degree	score	eigenvector	score	Between.	score	closeness	score
PC-FCCO	4	PC-FCCO	74.043	PC-FCCO	50	PC-FCCO	100
Secretariat 2	3	Secretariat 1	68.171	JNUV-FCCO	0	Secretariat 2	87.5
Secretariat 1	3	Secretariat 2	68.171	Secretariat 1	0	Secretariat 1	87.5
Secretariat 4	3	Secretariat 4	68.171	Secretariat 2	0	Secretariat 4	87.5
JNUV-FCCO	1	JNUV-FCCO	23.992	Secretariat 4	0	JNUV-FCCO	62.5

Time 41 Net. Size 3

degree	score	eigenvector	score	Between.	score	closeness	score
Secretariat 1	2	Secretariat 1	81.65	Secretariat 1	0	Secretariat 1	100.00
PC-FCCO	2	PC-FCCO	81.65	PC-FCCO	0	PC-FCCO	100.00
Secretariat 4	2	Secretariat 4	81.65	Secretariat 4	0	Secretariat 4	100.00

D. TOPOGRAPHICAL MEASURES AND CENTRALIZATION

Time n=quarter ==>41					
Time	**1-2**	**Time**	**3**	**Time**	**4**
size	11	size	9	size	8
Avg. degree	3.6	Avg. degree	3.1	Avg. degree	3.2
Density	0.36	Density	0.38	Density	0.46
Degree centralization (%)	37.00	Degree centralization	62.50	Degree centralization	52.38
Degree standard deviation	1.30	Degree standard deviation	1.91	Degree standard deviation	1.64
Eigenvector centralization (%)	52.96 percent	Eigenvector centralization	50.79 percent	Eigenvector centralization	43.88
Eigenvector standard deviation (norm.)	21.34	Eigenvector standard deviation (norm.)	24.24	Eigenvector standard deviation (norm.)	24.35
Betweenness centralization (%)	55.33	Betweenness centralization	71.88	Betweenness centralization	62.59
Betweenness standard deviation (norm.)	16.64	Betweenness standard deviation (norm.)	23.90	Betweenness standard deviation (norm.)	22.71
Closeness centralization (%)	48.20	Closeness centralization	65.29	Closeness centralization	56.01
Closeness standard deviation (norm.)	7.67	Closeness standard deviation (norm.)	13.92	Closeness standard deviation (norm.)	13.93
Clustering Coefficient (wtd)	0.58	Clustering Coefficient	0.65	Clustering Coefficient	0.75
Time	**5-9**	**Time**	**10-19**	**Time**	**20-28**
size	7	size	6	size	16
Avg. degree	3.4	Avg. degree	2.6	Avg. degree	7.6
Density	0.57	Density	0.53	Density	0.50
Degree centralization (%)	36.67	Degree centralization	40.00	Degree centralization	25.71
Degree standard deviation	1.29	Degree standard deviation	0.94	Degree standard deviation	3.20
Eigenvector centralization (%)	34.67 t	Eigenvector centralization	47.93	Eigenvector centralization	21.08
Eigenvector standard deviation (norm.)	23.78	Eigenvector standard deviation (norm.)	24.97	Eigenvector standard deviation (norm.)	19.36
Betweenness centralization (%)	47.78	Betweenness centralization	52.00	Betweenness centralization	42.67
Betweenness standard deviation (norm.)	20.29	Betweenness standard deviation (norm.)	24.27	Betweenness standard deviation (norm.)	16.27
Closeness centralization (%)	41.76	Closeness centralization	45.00	Closeness centralization	35.29
Closeness standard deviation (norm.)	13.32	Closeness standard deviation (norm.)	12.02	Closeness standard deviation (norm.)	14.30
Clustering Coefficient (wtd)	0.86	Clustering Coefficient	0.75	Clustering Coefficient	0.94

Topographical Measures and Centralization (continued)

Time	29-38	Time	39-40	Time	41
size	6	size	5	size	3
Avg. degree	2.6	Avg. degree	2.8	Avg. degree	2.0
Density	0.53	Density	0.70	Density	1.00
Degree centralization (%)	40.00	Degree centralization	50.00	Degree centralization	0.00 t
Degree standard deviation	0.94	Degree standard deviation	0.07	Degree standard deviation	0.00
Eigenvector centralization (%)	47.93	Eigenvector centralization	33.83	Eigenvector centralization	0.00
Eigenvector standard deviation (norm.)	24.97	Eigenvector standard deviation (norm.)	18.40	Eigenvector standard deviation (norm.)	0.00
Betweenness centralization (%)	52.00	Betweenness centralization	50.00	Betweenness centralization	0.00
Betweenness standard deviation (norm.)	24.27	Betweenness standard deviation (norm.)	20.00	Betweenness standard deviation (norm.)	0.00
Closeness centralization (%)	45.00	Closeness centralization	43.75	Closeness centralization	0.00
Closeness standard deviation (norm.)	12.02	Closeness standard deviation (norm.)	12.25	Closeness standard deviation (norm.)	0.00
Clustering Coefficient (wtd)	0.75	Clustering Coefficient	0.80	Clustering Coefficient	1.00

E. NETWORK TRANSFORMATION OVER TIME
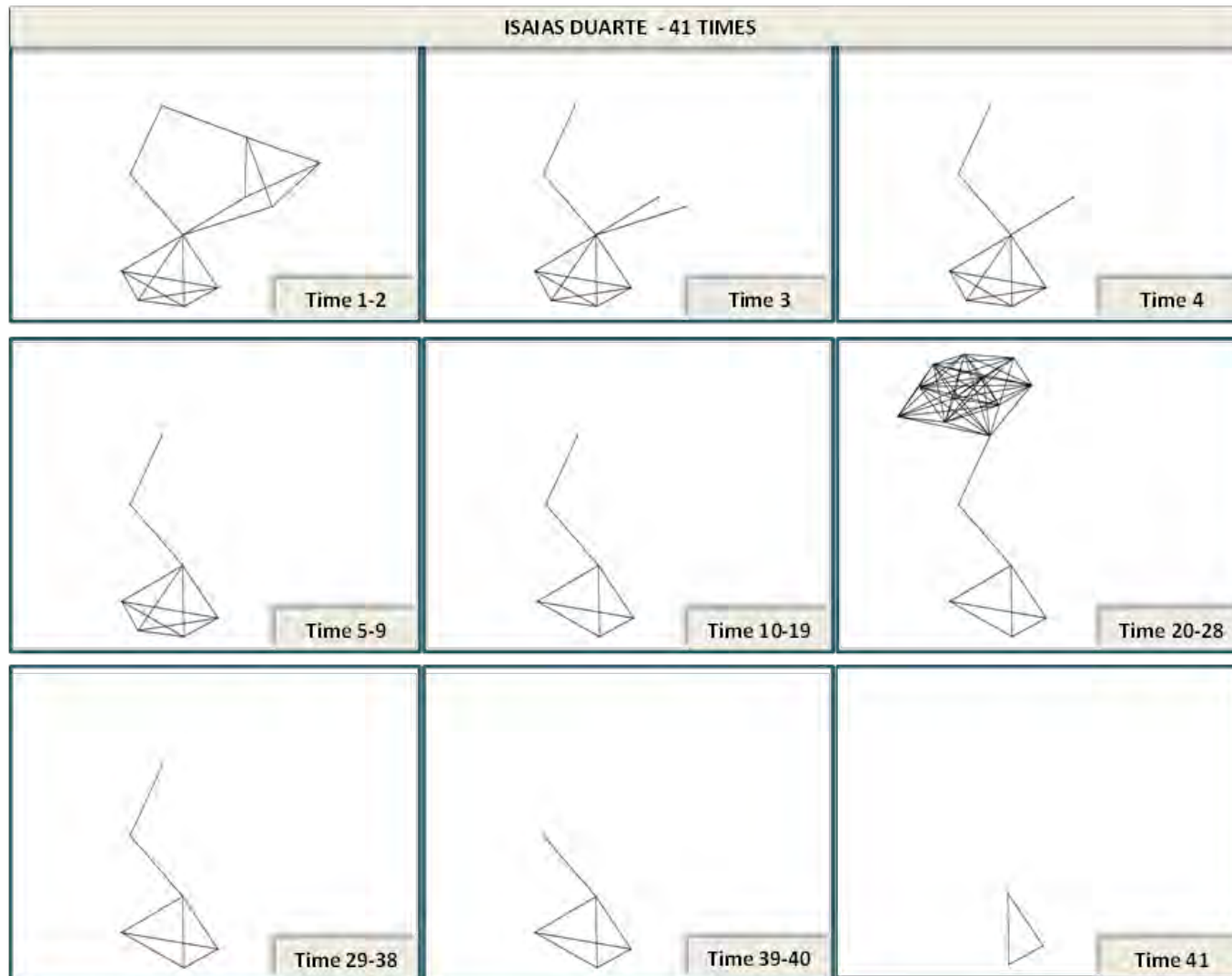
ISAIAS DUARTE - 41 TIMES

Time 1-2

Time 3

Time 4

Time 5-9

Time 10-19

Time 20-28

Time 29-38

Time 39-40

Time 41

90

F. SOCIAL NETWORK CHANGE DETECTION

Betweenness network centralization - Change Detection

--*-- Decrease --*-- **Increase**

Closeness network centralization

--*-- Decrease --*-- **Increase**

Eigenvector network centralization

--*-- Decrease --*-- **Increase**

Degree network centralization
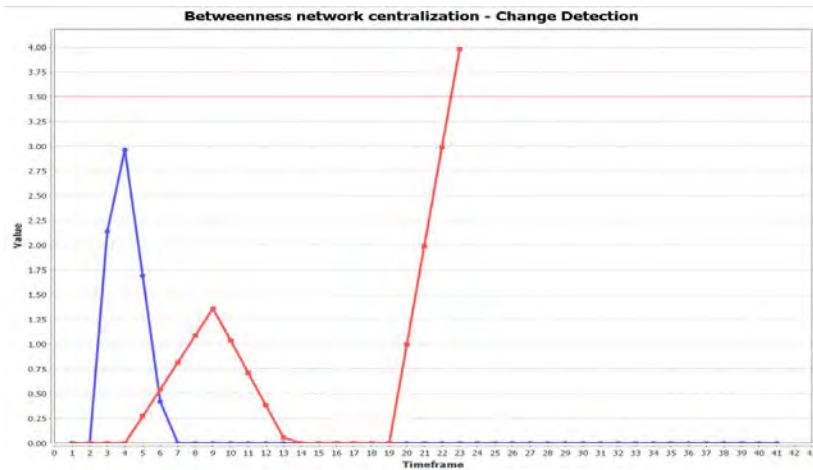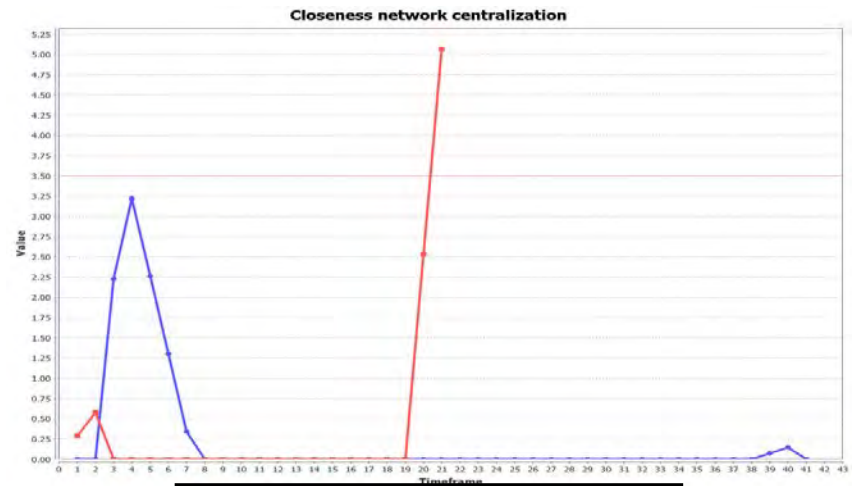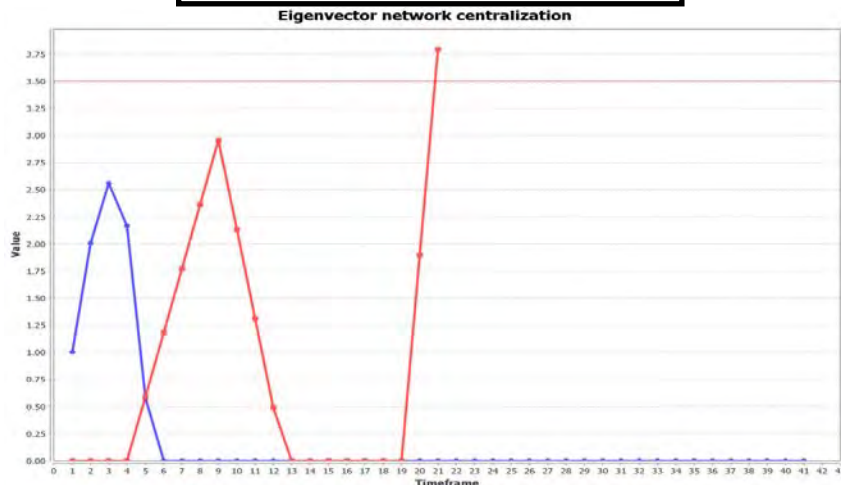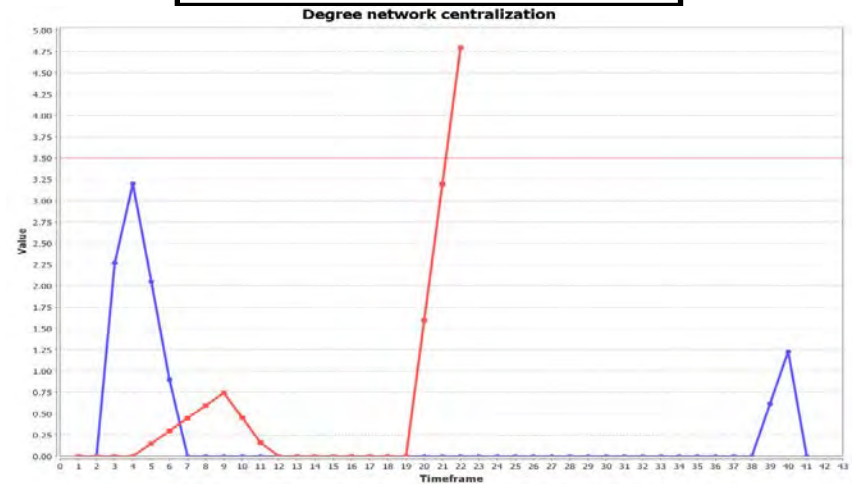
--*-- Decrease --*-- **Increase**

Social Network Change Detection (continued)

Clustering Coefficient - Change Detection
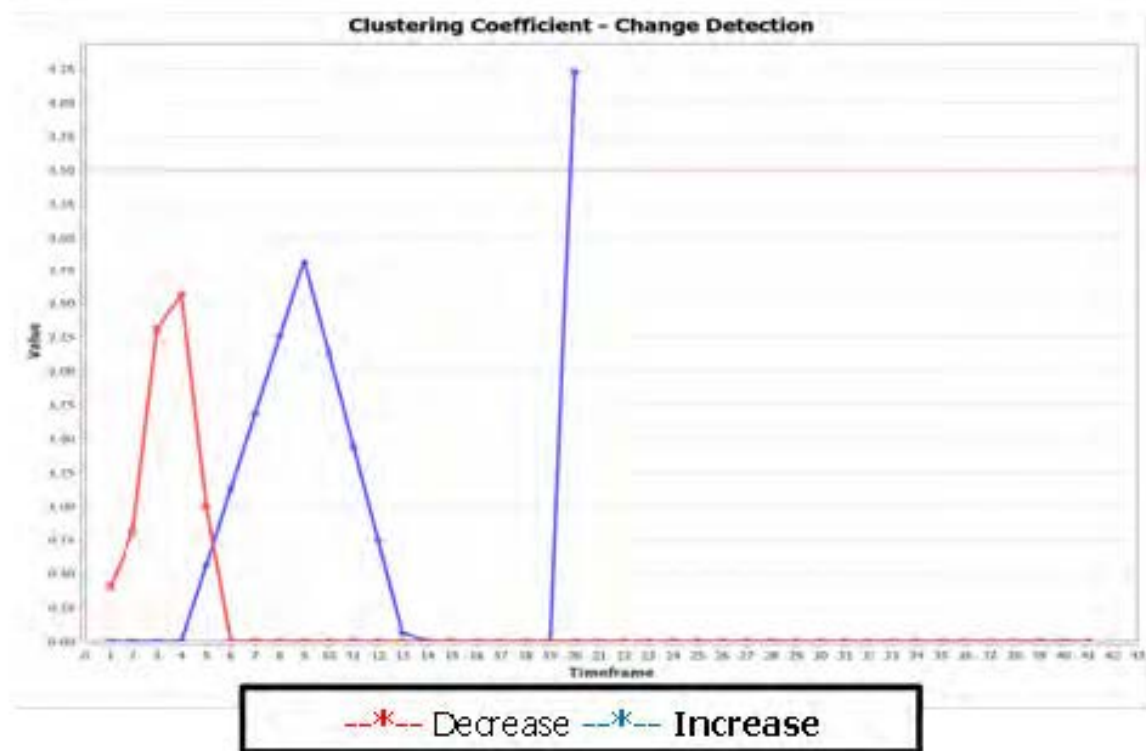
APPENDIX 2. EL NOGAL CASE STUDY

A.   LIST OF OPEN SOURCES

Source	Title (in original language)	Date	Internet link
Semana	¿Quién puso la bomba en el Club El Nogal? [Who placed the IED in El Nogal?]	February 16, 2003	http://www.semana.com/nacion/articulo/quien-puso-bomba-club-el-nogal/56489-3
El Tiempo	A Arellán le dijeron que El Nogal volaba a las 10 p.m. [Arellan was told the El Nogal exploded at 10 p.m]	February 27, 2003	http://www.eltiempo.com/archivo/documento-2013/MAM-984494
Semana	Las Farc preparaban atentado contra el Hospital Militar [The FARC planned an attack on the Military Hospital]	April 13, 2003	http://www.semana.com/noticias/articulo/las-farc-preparaban-atentado-contra-hospital-militar/57615-3
Caracol	Habría muerto "El Mocho" de FARC y diez de sus comandados ["El Mocho" from the FARC is dead with 10 of his men]	October 20, 2003	http://www.caracol.com.co/noticias/judiciales/habria-muerto-el-mocho-de-farc-y-diez-de-sus-comandados/20031020/nota/85435.aspx
El Tiempo	Secretariado ordenó contra El Nogal [The Secretariat ordered against El Nogal]	December 18, 2003	http://www.eltiempo.com/archivo/documento/MAM-1049213
El País	Fiscalía esclarece el atentado a El Nogal [Attorney General clarifies attack on El Nogal]	December 18, 2003	http://historico.elpais.com.co/paisonline/notas/Diciembre182003/A618N4.html
El Tiempo	Las piezas secretas de El Nogal [The secret pieces of El Nogal]	December 21, 2003	http://www.eltiempo.com/archivo/documento/MAM-104686
El Tiempo	Aguja , el reclutador del atentado al club El Nogal [Aguja, the recruiter for the attack on El Nogal]	June 13, 2005	http://www.eltiempo.com/archivo/documento/MAM-1956252

List of Open Sources (continued)

Source	Title (in original language)	Date	Internet link
El Colombiano	Fernando Arellán irá a juicio por atentado a Club El Nogal [Fernando Arellán goes to trial for attack on El Nogal]	November 14, 2005	http://www.elcolombiano.com/ BancoConocimiento/ O/olac_arellan_ira_juicio_colpren sa_ana_20051114/ olac_arellan_ira_juicio_colprensa _ana_20051114.asp
El País	Se inicia el juicio por ataque al Club El Nogal [Trial for attack on El Nogal begins]	November 15, 2005	http://historico.elpais.com.co/ paisonline/notas/ Noviembre152005/A515N1.html
Colombian Air Force press	La guerrilla de las Farc tenía planeado atentar contra el Hospital Militar, en Bogotá [The FARC had planned to attack the Military Hospital in Bogotá]	December 2, 2005	https://www.fac.mil.co/?idcategori a=5619
Caracol	Capturada la mujer que presuntamente suministró los explosivos para el atentado al Nogal [Woman arrested that provided explosives used in the attack on El Nogal]	March 13, 2007	http://www.caracol.com.co/ noticias/judiciales/capturada-la- mujer-que-presuntamente- suministro-los-explosivos-para-el- atentado-al-nogal/20070313/ nota/401828.aspx
El Espectador	Capturan a responsable de atentado a El Nogal [Arrested one responsible of attack on El Nogal]	October 30, 2008	HTTP://WWW.ELESPECTADOR. COM/NOTICIAS/JUDICIAL/ ARTICULO86978-CAPTURAN- RESPONSABLE-DE- ATENTADO-EL-NOGAL
El Espectador	Condenan a 40 años de prisión a responsables de atentado en club El Nogal [40 year prison sentence to those responsible of attack on El Nogal]	December 1, 2008	http://www.elespectador.com/ noticias/judicial/articulo95151- condenan-40-anos-de-prision- responsables-de-atentado-club- el-nogal

List of Open Sources (continued)

Source	Title (in original language)	Date	Internet link
El Espectador	Autor de atentado al Nogal estará 40 años en la cárcel [Perpetrator of attack on El Nogal will serve 40 years of prison]	January 26, 2009	http://www.elespectador.com/ noticias/judicial/articulo111761-autor-de-atentado-al-nogal-estara-40-anos-carcel
El Espectador	Capturan a hermanos presuntamente implicados en atentado a 'El Nogal' [Arrested brothers allegedly involved in attack on El Nogal]	August 28, 2009	http://www.elespectador.com/ noticias/judicial/articulo158434-capturan-hermanos-presuntamente-implicados-atentado-el-nogal
El Espectador	Condenan a 40 años a guerrillero que participó en atentado a 'El Nogal' [Conviction of 40 years to terrorist involved in attack on El Nogal]	September 11, 2009	http://www.elespectador.com/ noticias/judicial/articulo160823-condenan-40-anos-guerrillero-participo-atentado-el-nogal
El Espectador	Correos del 'Mono Jojoy' revelan cómo se planeó atentado contra El Nogal [Emails from 'Mono Jojoy' reveal how the attack on El Nogal was planned]	October 16, 2010	http://www.elespectador.com/ noticias/judicial/correos-del-mono-jojoy-revelan-se-planeo-atentado-contr-articulo-230048

El Espectador	Capturan autor del atentado al club El Nogal [Perpetrator arrested for attack on El Nogal]	March 5, 2011	http://www.elespectador.com/noticias/judicial/capturan-autor-del-atentado-al-club-el-nogal-articulo-255039
El Espectador	Pagará una condena de 40 años de prisión el terrorista de El Nogal [Terrorist of El Nogal will serve 40 years of prison]	March 6, 2011	http://www.elespectador.com/noticias/judicial/el-terrorista-de-el-nogal-articulo-255159
Supreme Criminal Court	Negación de casación [Denial of appeal]	April 11, 2012	http://www.usergioarboleda.edu.co/derecho_penal/jurisprudencia_2012/jurisprudencia_segundo_trimestre_2012/36123(11-04-12).pdf
El Tiempo	Los computadores de las FARC dieron la clave [The FARC computers were the key]	February 2, 2013	http://www.eltiempo.com/Multimedia/especiales/atentado/el/nogal/los-computadores-de-las-farc-dieron-la-clave_12574121-7
W radio	Los líderes de las Farc que permanecen en Colombia [The FARC leaders remaining in Colombia]	February 28, 2014	http://www.wradio.com.co/noticias/actualidad/los-lideres-de-las-farc-que-permanecen-en-colombia/20140228/nota/2105792.aspx

B.   TIMELINE

Date	Type of event	Description	Timeframe
11/30/2002	Logistics	Acquisition of the workshop to load vehicle with explosives	1
12/2/2002	Logistics	CMTF provides explosives to the terrorist organization	1
12/3/2002	Logistics	Explosive transported to Bogotá on a "chiva rumbera" (party bus)	1
12/9/2002	Logistics	Logistic members of the FARC got involved in conditioning the car bomb	1
1/31/2003	Logistics	Terrorists bought a Chevrolet Megan used as car bomb. They paid in cash.	1
1/31/2003	Meeting	Meeting between AMB, the criminal organization, DAPPA and WDR	1
2/6/2003	Logistics	Car is loaded with explosives.	1
2/6/2003	Meeting	FARC members decided to kill members of the criminal gang.	1
2/7/2003	Terrorist attack	Execution of the terrorist attack on El Nogal Club	2
4/4/2003	Law enforcement operation (L.E.O)	Arrested members of the terrorist network - AMB and FGRG	2
8/30/2003	Investigation	Member of CMTF defects and becomes witness	4
10/19/2003	Military operation	KIA member of the FARC's CMTF	4
11/1/2003	Death	Death of a FARC leader	5
12/20/2003	(L.E.O)	Arrested FARC member in Bogotá	5
5/1/2004	(L.E.O)	Arrested members of the terrorist network	7
9/30/2005	(L.E.O)	Member of the criminal gang arrested	12
3/12/2007	(L.E.O)	Arrested members of the terrorist network	21
3/1/2008	(L.E.O)	KIA member of the FARC's secretariat	22
3/26/2008	Death	Death of the FARC's top commander	22
8/28/2009	(L.E.O)	Arrested personal contacts of VJVV. Requested on extradition by the U.S.	28
9/22/2010	(L.E.O)	KIA member of the FARC's secretariat	32
3/5/2011	(L.E.O)	Arrest of a criminal gang member	34
11/4/2011	(L.E.O)	KIA member of the FARC's secretariat	37

C.   CENTRALITY MEASURES OVER TIME

TOP 10 X TIME							
Time 1–2 - Net. Size 27							
degree	**score**	**eigenvector**	**score**	**Between.**	**score**	**closeness**	**score**
HDVSAP	10	MJTR-BS	50.89	HDVSAP	54.65	HDVSAP	69.231
HABAP	8	VJSR-BS	50.891	VJVV	22.872	HABAP	61.538
MJTR-BS	8	Secretariat 4	48.32	VJSR-BS	17.53	WDR FARC-CMTF defector	59.615
JFAZ	8	Secretariat 3	48.32	MJTR-BS	17.53	VJSR-BS	58.974
VJSR-BS	8	Secretariat 2	48.32	HABAP	15.85	MJTR-BS	58.974
WDR FARC-CMTF defector	8	Secretariat 5	48.327	WDR FARC-CMTF defector	10.415	VJVV	57.692
Secretariat 1	7	Secretariat 1	48.32	APAN	4.154	JFAZ	56.41
Secretariat 2	7	Secretariat 6	48.32	JFAZ	3.959	OAB	53.846
Secretariat 3	7	HDVSAP	20.78	FGRG	3.795	AJALM	53.205
OAB	7	WDR FARC-CMTF defector	7.577	LVVL	1.744	FGRG	51.923
Time 3–4 Net. Size 19							
degree	**score**	**eigenvector**	**score**	**Between.**	**score**	**closeness**	**score**
HDVSAP	8	MJTR-BS	51.13	HDVSAP	65.90	HDVSAP	72.222
MJTR-BS	8	VJSR-BS	51.13	VJVV	29.41	MJTR-BS	68.519
VJSR-BS	8	Secretariat 4	49.02	MJTR-BS	21.56	VJSR-BS	68.519
Secretariat 3	7	Secretariat 3	49.02	VJSR-BS	21.56	Secretariat 3	58.333
Secretariat 5	7	Secretariat 2	49.02	HABAP	7.516	VJVV	58.333
Secretariat 4	7	Secretariat 5	49.02	WDR FARC-CMTF defector	4.575	Secretariat 4	58.333
Secretariat 6	7	Secretariat 1	49.02	EGNMM	0.218	Secretariat 6	58.333
Secretariat 1	7	Secretariat 6	49.02	FAB	0.218	Secretariat 1	58.333
Secretariat 2	7	HDVSAP	17.07			Secretariat 2	58.333
VJVV	5	HABAP	3.472			Secretariat 5	58.333

Centrality measures over time (continued)

Time 5 Net. Size 17							
degree	score	eigenvector	score	between.	score	closeness	score
MJTR-BS	8	MJTR-BS	51.10	HDVSAP	51.66	MJTR-BS	67.70
VJSR-BS	8	VJSR-BS	51.10	VJVV	30	VJSR-BS	67.70
Secretariat 4	7	Secretariat 4	49.18	MJTR-BS	20	HDVSAP	62.5
Secretariat 3	7	Secretariat 3	49.18	VJSR-BS	20	Secretariat 3	59.37
Secretariat 2	7	Secretariat 2	49.18	HABAP	11.66	Secretariat 2	59.37
Secretariat 5	7	Secretariat 5	49.18			Secretariat 5	59.37
Secretariat 6	7	Secretariat 1	49.18			Secretariat 6	59.37
Secretariat 1	7	Secretariat 6	49.18			Secretariat 4	59.37
VJVV	5	HDVSAP	15.51			Secretariat 1	59.37
HDVSAP	5	VJVV	2.799			VJVV	56.25
Time 6–7 Net. Size 15							
degree	score	eigenvector	score	between.	score	closeness	score
VJSR-BS	7	MJTR-BS	54.82	HDVSAP	46.15	VJSR-BS	66.66
MJTR-BS	7	VJSR-BS	54.82	VJVV	32.96	MJTR-BS	66.66
Secretariat 5	6	Secretariat 4	52.10	MJTR-BS	19.23	HDVSAP	60.71
Secretariat 4	6	Secretariat 2	52.10	VJSR-BS	19.23	VJVV	58.33
Secretariat 1	6	Secretariat 5	52.10	HABAP	13.18	Secretariat 4	58.33
Secretariat 6	6	Secretariat 1	52.10			Secretariat 6	58.33
Secretariat 2	6	Secretariat 6	52.10			Secretariat 2	58.33
VJVV	5	HDVSAP	19.32			Secretariat 1	58.33
HDVSAP	4	VJVV	4.338			Secretariat 5	58.33
RCR acquainted with VJVV	3	HABAP	3.984			HABAP	51.19

Centrality measures over time (continued)

Time 8–12 Net. Size 14							
degree	score	eigenvector	score	between.	score	closeness	score
MJTR-BS	7	MJTR-BS	54.827	HDVSAP	17.949	MJTR-BS	60.256
VJSR-BS	7	VJSR-BS	54.827	HABAP	10.256	VJSR-BS	60.256
Secret.4	6	Secret. 4	52.223	VJSR-BS	9.615	Secret.6	54.487
Secret. 1	6	Secret.2	52.223	MJTR-BS	9.615	Secret. 1	54.487
Secret. 6	6	Secret.5	52.223			Secret. 5	54.487
Secret. 2	6	Secret.1	52.223			Secret. 4	54.487
Secret. 5	6	Secret. 6	52.223			Secret. 2	54.487
HDVSAP	3	HDVSAP	18.487			HDVSAP	46.154
RCR acquainted with VJVV	2	HABAP	3.115			HABAP	35.897
CACR acquainted with VJVV	2	FAB	0.511			FAB	26.282
Time 13–21 Net. Size 13							
degree	score	eigenvector	score	between.	score	closeness	score
MJTR-BS	7	MJTR-BS	54.827	HDVSAP	10.606	MJTR-BS	62.5
VJSR-BS	7	VJSR-BS	54.827	MJTR-BS	7.576	VJSR-BS	62.5
Secretariat 4	6	Secretariat 4	52.225	VJSR-BS	7.576	Secret.1	56.944
Secretariat 1	6	Secretariat 2	52.225			Secretariat 6	56.944
Secretariat 6	6	Secretariat 5	52.225			Secretariat 5	56.944
Secretariat 2	6	Secretariat 1	52.225			Secretariat 4	56.944
Secretariat 5	6	Secretariat 6	52.225			Secretariat 2	56.944
HDVSAP	3	HDVSAP	18.474			HDVSAP	45.833
RCR acquainted with VJVV	2	HABAP	3.029			HABAP	30.556
CACR acquainted with VJVV	2					RCR acquainted with VJVV	16.667

100

Centrality measures over time (continued)

degree	score	eigenvector	score	between.	score	closeness	score
Time 22 Net. Size 12							
VJSR-BS	7	VJSR-BS	56.86	HDVSAP	12.72	VJSR-BS	68.18
Secret. 1	6	Secret. 2	54.10	VJSR-BS	11.27	MJTR-BS	63.63
MJTR-BS	6	Secret. 5	54.10	MJTR-BS	7.273	Secret. 1	62.12
Secret. 6	6	Secret. 1	54.10	Secret. 1	0.364	Secret. 6	62.12
Secret. 2	6	Secret. 6	54.10	Secret. 6	0.364	Secret. 5	62.12
Secret. 5	6	MJTR-BS	50.02	Secret. 2	0.364	Secret. 2	62.12
Secret. 4	5	Secret. 4	46.79	Secret. 5	0.364	Secret. 4	57.57
HDVSAP	3	HDVSAP	18.85			HDVSAP	50
CACR acquainted with VJVV	2	HABAP	3.228			HABAP	33.33
RCR acquainted with VJVV	2					RCR acquainted with VJVV	18.18
Time 23–28 Net. Size 10							
MJTR-BS	5	MJTR-BS	65.12	HDVSAP	13.889	MJTR-BS	61.111
VJSR-BS	5	VJSR-BS	65.12	VJSR-BS	8.333	VJSR-BS	61.111
Secretariat 1	4	Secretariat 5	58.837	MJTR-BS	8.333	Secretariat 1	53.704
Secretariat 5	4	Secretariat 1	58.837			Secretariat 5	53.704
Secretariat 6	4	Secretariat 6	58.837			Secretariat 6	53.704
HDVSAP	3	HDVSAP	32.755			HDVSAP	50
RCR acquainted with VJVV	2	HABAP	7.774			HABAP	33.333
MTCR acquainted with VJVV	2					RCR acquainted with VJVV	22.222
CACR acquainted with VJVV	2					CACR acquainted with VJVV	22.222
HABAP	1					MTCR acquainted with VJVV	22.222

degree	score	eigenvector	score	between.	score	closeness	score
Time 29–32 Net. Size 7							
MJTR-BS	5	MJTR-BS	65.12	HDVSAP	33.33	MJTR-BS	91.6
VJSR-BS	5	VJSR-BS	65.12	VJSR-BS	20	VJSR-BS	91.66
Secret. 6	4	Secretariat 5	58.83	MJTR-BS	20	Secret. 6	80.55
Secret.t 5	4	Secretariat 1	58.83			Secret. 5	80.55
Secretariat 1	4	Secretariat 6	58.83			Secretariat 1	80.55
HDVSAP	3	HDVSAP	32.75			HDVSAP	75
HABAP	1	HABAP	7.774			HABAP	50
Time 33–34 Net. Size 6							
degree	score	eigenvector	score	between.	score	closeness	score
MJTR-BS	4	MJTR-BS	74.13	MJTR-BS	60	MJTR-BS	90
Secret. 6	3	Secretariat 5	67.61	HDVSAP	40	Secret. 6	76.66
Secretariat 5	3	Secretariat 1	67.61			Secretariat 5	76.66
Secret. 1	3	Secretariat 6	67.61			Secret. 1	76.66
HDVSAP	2	HDVSAP	26.73			HDVSAP	70
HABAP	1	HABAP	8.632			HABAP	50
Time 35–37 Net. Size 5							
degree	score	eigenvector	score	between.	score	closeness	score
MJTR-BS	4	MJTR-BS	74.04	MJTR-BS	50	MJTR-BS	100
Secret. 5	3	Secretariat 5	68.17			Secret. 5	87.5
Secret. 1	3	Secretariat 1	68.17			Secret. 1	87.5
Secret. 6	3	Secretariat 6	68.17			Secret. 6	87.5
HDVSAP	1	HDVSAP	23.99			HDVSAP	62.5
Time 38 Net. Size 4							
degree	score	eigenvector	score	between.	score	closeness	score
MJTR-BS	3	MJTR-BS	86.49	MJTR-BS	66.67	MJTR-BS	100
Secret.1	2	Secretariat 1	73.92			Secret.1	83.33
Secret. 6	2	Secretariat 6	73.92			Secret. 6	83.33
HDVSAP	1	HDVSAP	39.85			HDVSAP	66.66

D.   TOPOGRAPHICAL MEASURES AND CENTRALIZATION

Time n=quarter ==>38					
Time	**1-2**	**Time**	**3-4**	**Time**	**5**
size	27	size	19	size	17
Avg. degree	5.7	Avg. degree	5	Avg. degree	4.8
Density	0.22	Density	0.28	Density	0.3
Degree centralization (%)	17.54	Degree centralization	18.30	Degree centralization	22.50
Degree standard deviation	2.01	Degree standard deviation	2.33	Degree standard deviation	2.60
Eigenvector centralization (%)	42.45	Eigenvector centralization	38.99	Eigenvector centralization	37.19
Eigenvector standard deviation (norm.)	20.39	Eigenvector standard deviation (norm.)	22.99	Eigenvector standard deviation (norm.)	23.64
Betweenness centralization (%)	50.72	Betweenness centralization	61.18	Betweenness centralization	46.56
Betweenness standard deviation (norm.)	11.59	Betweenness standard deviation (norm.)	16.25	Betweenness standard deviation (norm.)	14.27
Closeness centralization (%)	38.02	Closeness centralization	38.13	Closeness centralization	37.27
Closeness standard deviation (norm.)	6.49	Closeness standard deviation (norm.)	8.99	Closeness standard deviation (norm.)	16.00
Clustering Coefficient (wtd)	0.66	Clustering Coefficient (wtd)	0.79	Clustering Coefficient (wtd)	0.87
Time	**6-7**	**Time**	**8-12**	**Time**	**13-21**
size	15	size	14	size	13
Avg. degree	4.4	Avg. degree	4	Avg. degree	4
Density	0.31	Density	0.3	Density	0.34
Degree centralization (%)	21.43	Degree centralization	26.92	Degree centralization	28.03
Degree standard deviation	2.09	Degree standard deviation	2.39	Degree standard deviation	2.41
Eigenvector centralization (%)	41.02	Eigenvector centralization	39.88	Eigenvector centralization	37.54
Eigenvector standard deviation (norm.)	24.83	Eigenvector standard deviation (norm.)	25.32	Eigenvector standard deviation (norm.)	25.06
Betweenness centralization (%)	40.11	Betweenness centralization	15.68	Betweenness centralization	9.34
Betweenness standard deviation (norm.)	14.12	Betweenness standard deviation (norm.)	5.68	Betweenness standard deviation (norm.)	3.68
Closeness centralization (%)	34.97 %	Closeness centralization	47.46 %	Closeness centralization	48.16 %
Closeness standard deviation (norm.)	16.09	Closeness standard deviation (norm.)	19.86	Closeness standard deviation (norm.)	21.09
Clustering Coefficient (wtd)	0.85	Clustering Coefficient (wtd)	0.90	Clustering Coefficient (wtd)	0.90

Topographical Measures and Centralization (continued)

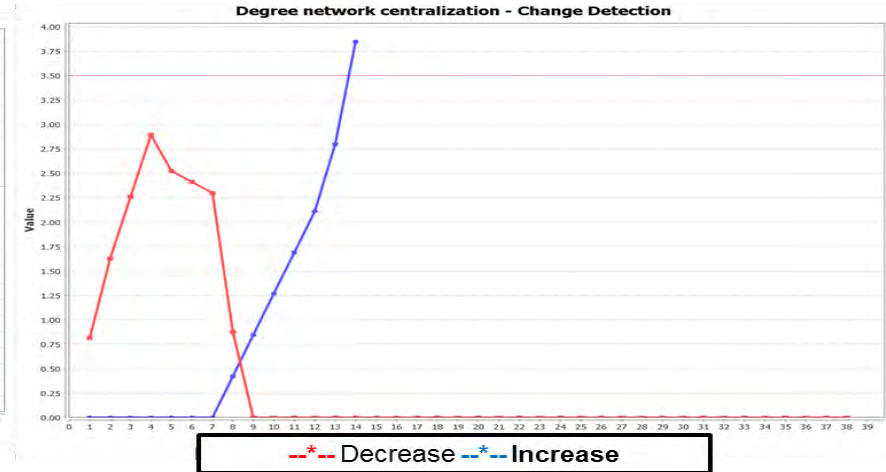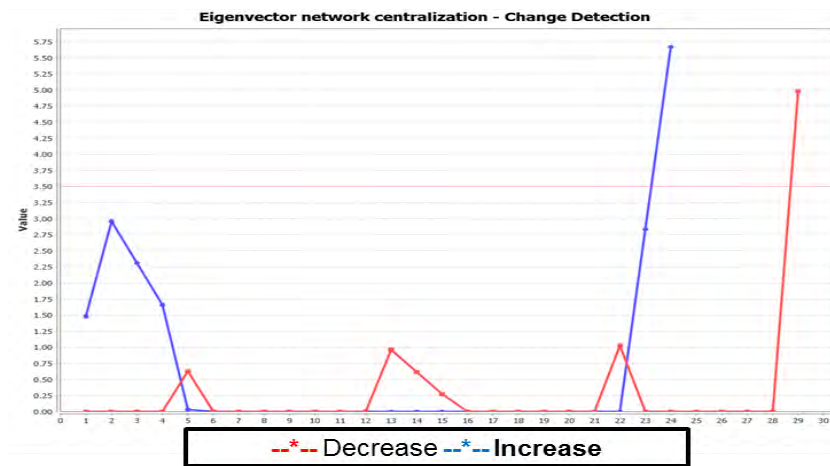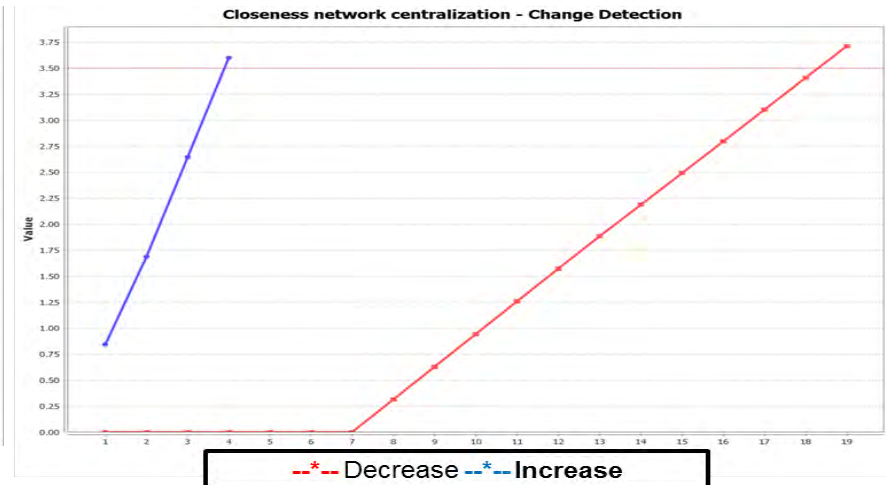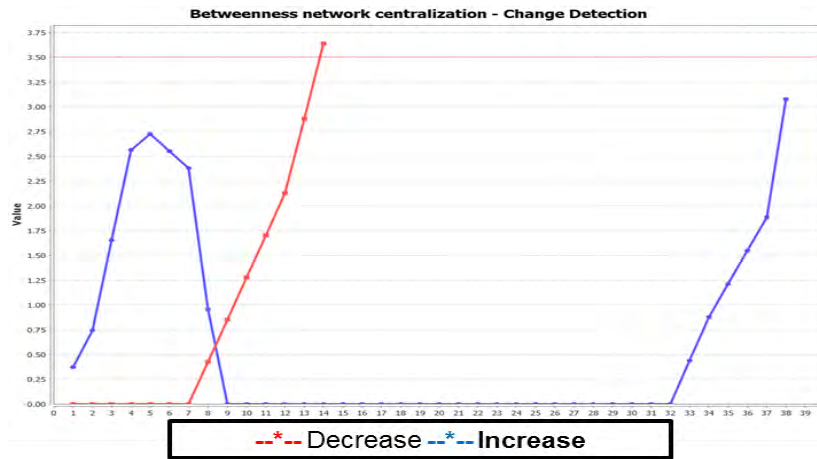| Time	22	Time	23-28	Time	29-32
size	12	size	10	size	7
Avg. degree	4.3	Avg. degree	3.2	Avg. degree	3.7
Density	0.39	Density	0.35	Density	0.61
Degree centralization (%)	29.09	Degree centralization	25.00	Degree centralization	30.00
Degree standard deviation	2.06	Degree standard deviation	1.33	Degree standard deviation	1.28
Eigenvector centralization (%)	37.76	Eigenvector centralization	50.65	Eigenvector centralization	30.58
Eigenvector standard deviation (norm.)	24.47	Eigenvector standard deviation (norm.)	28.18	Eigenvector standard deviation (norm.)	19.90
Betweenness centralization (%)	10.91	Betweenness centralization	12.04	Betweenness centralization	26.67
Betweenness standard deviation (norm.)	4.59	Betweenness standard deviation (norm.)	4.88	Betweenness standard deviation (norm.)	12.78
Closeness centralization (%)	46.28	Closeness centralization	41.98	Closeness centralization	33.61
Closeness standard deviation (norm.)	19.21	Closeness standard deviation (norm.)	15.61	Closeness standard deviation (norm.)	13.01
Clustering Coefficient (wtd)	0.86	Clustering Coefficient (wtd)	0.82	Clustering Coefficient (wtd)	0.81
Time	33-34	Time	35-37	Time	38
size	6	size	5	size	4
Avg. degree	2.6	Avg. degree	2.8	Avg. degree	2
Density	0.53	Density	0.7	Density	0.66
Degree centralization (%)	40.00	Degree centralization	50.00	Degree centralization	66.67
Degree standard deviation	0.94	Degree standard deviation	0.98	Degree standard deviation	0.71
Eigenvector centralization (%)	47.93	Eigenvector centralization	33.83	Eigenvector centralization	56.62
Eigenvector standard deviation (norm.)	24.97	Eigenvector standard deviation (norm.)	18.40	Eigenvector standard deviation (norm.)	17.34
Betweenness centralization (%)	52.00	Betweenness centralization	50.00	Betweenness centralization	66.67
Betweenness standard deviation (norm.)	24.27	Betweenness standard deviation (norm.)	20.00	Betweenness standard deviation (norm.)	28.87
Closeness centralization (%)	45.00	Closeness centralization	43.75	Closeness centralization	55.56
Closeness standard deviation (norm.)	12.02	Closeness standard deviation (norm.)	12.25	Closeness standard deviation (norm.)	11.79
Clustering Coefficient (wtd)	0.75	Clustering Coefficient (wtd)	0.80	Clustering Coefficient (wtd)	0.60

E. NETWORK TRANSFORMATION OVER TIME

EL NOGAL CLUB - 38 TIMES

Time 1-2

Time 3-4

Time 5

Time 6-7

Time 8-12

Time 13-21

Time 22

Time 23-28

Time 29-32

Time 33-34

Time 35-37

Time 38

F.   SOCIAL NETWORK CHANGE DETECTION

Betweenness network centralization – Change Detection

Closeness network centralization – Change Detection

Eigenvector network centralization – Change Detection
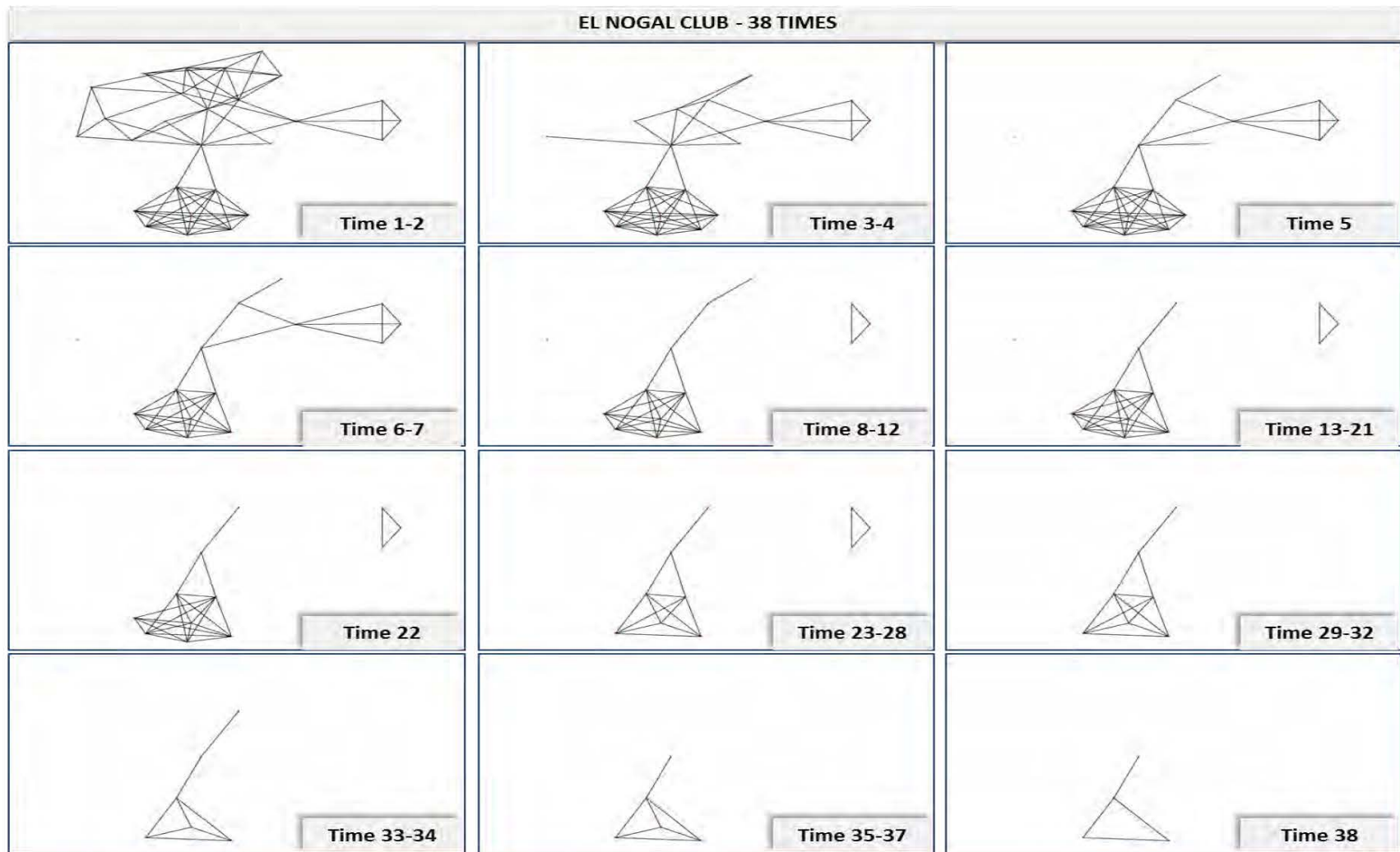
Degree network centralization – Change Detection

Social Network Change Detection (continued)

Clustering Coefficient - Change Detection
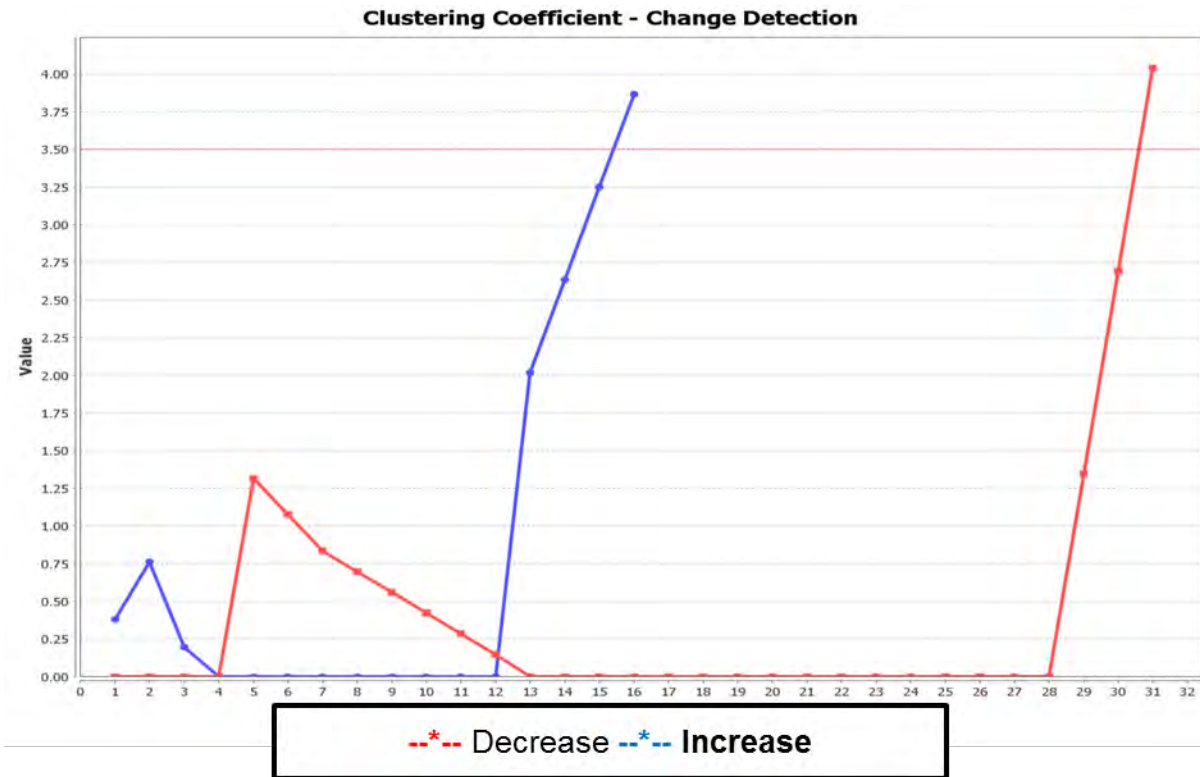
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APPENDIX 3. FERNANDO LONDOÑO CASE STUDY

A. LIST OF OPEN SOURCES

Source	Title (in original language)	Date	Internet link
El Espectador	¿Por qué contra Fernando Londoño Hoyos? [Why against Fernando Londoño Hoyos?]	May 15, 2012	http://www.elespectador.com/noticias/judicial/contra-fernando-londono-hoyos-articulo-346485
Caracol	Gobierno Confirma Que Fernando Londoño Habría Recibido Amenazas [Government confirms that Londoño had received threats]	May 16, 2012	http://www.caracol.com.co/noticias/judiciales/gobierno-confirma-que-fernando-londono-habia-recibido-amenazas/20120516/nota/1688946.aspx
El País	Las Farc asaltaron carro de valores en la vía Santander de Quilichao-Cali [The FARC assaulted a vehicle transporting valuables on the way between Santander and Cali]	October 24, 2012	http://www.elpais.com.co/elpais/judicial/noticias/dos-policias-heridos-dejo-ataque-carro-valores-panamericana
Semana	FARC secuestraron a dos policías en Valle [The FARC kidnapped two policemen in Valle]	January 26, 2013	http://m.semana.com/nacion/articulo/farc-secuestraron-dos-policias-valle/330948-3
Semana	¿Y Qué Tal Este Delincuente? [And, what about this criminal?]	February 2, 2013	http://www.semana.com/nacion/articulo/y-que-este-delincuente/331454-3
Caracol	Primeras Imágenes De La Liberación De Dos Policías Secuestrados Por FARC [First images of the release of two policemen kidnapped by the FARC]	February 15, 2013	http://www.noticiascaracol.com/nacion/primeras-imagenes-de-la-liberacion-de-dos-policias-secuestrados-por-farc
Caracol	Escrito de acusación [Bill of indictment]	February 21, 2013	http://www.caracol.com.co/docs/201302mareb1a63a.docx

Source	Title (in original language)	Date	Internet link
El Tiempo	'La Teófilo pagó $1.000 millones por atentado a Londoño' [The CMTF paid $1.000 million for the attack on Londoño]	March 1, 2013	http://www.eltiempo.com/archivo/documento/CMS-12626865
Fiscalía General de la Nación	Acusan a implicados en atentado en contra del exministro Fernando Londoño [Accused some involved in the attack on former Minister Londoño]	June 27, 2013	http://www.fiscalia.gov.co/colombia/noticias/acusan-a-implicados-en-atentado-en-contra-del-exministro-fernando-londono/
El Tiempo	'Musas' de las Farc cayeron por una 'SIM card' ['Muses' from the FARC fall because of a SIM card]	July 9, 2013	http://www.eltiempo.com/justicia/captura-de-las-musas-de-las-farc_12922354-4
Fiscalía General de la Nación	Legalizadas capturas por atentado en contra del ex ministro Londoño Hoyos [Legal capture of those involved in attack on Londoño]	August 29, 2013	http://www.fiscalia.gov.co/colombia/noticias/legalizadas-capturas-por-atentado-en-contra-del-ex-ministro-londono-hoyos/
El Tiempo	Carta Del Paisa, Clave En Proceso Por Atentado a Exministro Londoño [Letter from El Paisa, key in investigation of attack on former Minister Londoño]	November 18, 2013	http://www.eltiempo.com/archivo/documento/CMS-13200392
Diario del Huila	Enviadas a la cárcel 'fuerzas especiales' de las Farc [To jail FARC special forces]	February 26, 2014	http://diariodelhuila.com/judicial/enviadas-a-la-carcel-'fuerzas-especiales'-de-las-farc-cdgint201402260073620127
El Tiempo	El fin de la alianza de las Farc con el 'parche de Zuley' [The end of the alliance between the FARC and the Parche El Zuley]	May 1, 2014	http://www.eltiempo.com/justicia/alianza-de-las-farc-con-el-parche-de-zuley-llego-a-su-fin_13916279-4

B.   TIMELINE

Date	Type of Event	Description	Timeframe
4/26/2012	Planning of the attack	The PEZ members travel from Cali to Bogotá for gathering information on the target	1
4/25/2012	Meeting between criminals	The PEZ criminals contacted another criminal organization from Bogotá	1
5/7/2012	Planning of the attack	The PEZ Travels back to Cali in order to coordinate the acquisition of explosives	1
5/6/2012	Meeting between criminals	The PEZ contacted another criminal group from Cali	1
5/7/2012	Logistics	Criminals travel from Cali to Bogotá for planning the terrorist attack	2
5/9/2012	Logistics	Explosives prepared in Cali arrived to Bogotá	2
5/9/2012	Mobilization	Bomber and driver arrived to Bogotá from Cali	2
5/14/2012	Planning of the attack	Final arrangements for terrorist attack	2
5/15/2012	Execution of the operation	Terrorist attack against Fernando Londoño	2
6/1/2012	Network's dispersion	Terrorists escape to Cali city	3
8/28/2012	Law enforcement operation	Terrorists from Bogotá were arrested	5
6/12/2013	Law enforcement operation	Terrorists arrested during Police operation – they belong to the Sixth Front	15
8/18/2013	Law enforcement operation	Terrorists KIA during police operation	17
12/15/2013	Law enforcement operation	Terrorists KIA and arrested during Police operation	21
2/24/2014	Law enforcement operation	Terrorists arrested during Police operation	23

C. CENTRALITY MEASURES OVERTIME

TOP 10 X TIME							
Time 1–2 - Net. Size 11							
DEGREE	Score	EIGENVECTOR	Score	BETWEENNESS	Score	CLOSENESS	Score
DF-TM	9	DF-TM	52.07	HDVSAP	20	DF-TM	95
W-TM	9	W-TM	52.07	DF-TM	19.26	W-TM	95
LAMREG	8	LAMREG	50.29	W-TM	19.26	LAMREG	88.333
UCBA	7	UCBA	47.7	LAMREG	3.704	UCBA	83.333
CARGB	7	CARGB	47.7			CARGB	83.333
NACH	7	NACH	47.7			NACH	83.333
FCAF	7	FCAF	47.7			FCAF	83.333
CAPI	7	CAPI	47.7			CAPI	83.333
HDVSAP	3	JLGB	21.34			HDVSAP	65
JLGB	3	HDVSAP	14.67			JLGB	63.333
Time 3–5 Net. Size 25							
DEGREE	Score	EIGENVECTOR	Score	BETWEENNESS	Score	CLOSENESS	Score
DF-TM	13	W-TM	54.81	AMPAJ	38.06	DF-TM	77.083
W-TM	13	LAMREG	52.89	DF-TM	32.6	W-TM	77.083
LAMREG	12	DF-TM	51.24	W-TM	19.8	LAMREG	74.306
AMPAJ	10	UCBA	40.97	LAMREG	14.55	AMPAJ	70.139
UCBA	7	CARGB	40.97	HDVSAP	11.41	UCBA	59.028
CARGB	7	NACH	40.97	JLGB	2.826	CARGB	59.028
FCAF	7	FCAF	40.97	MAPSP	2.198	FCAF	59.028
CAPI	7	CAPI	40.97	GIVC	1.691	CAPI	59.028
NACH	7	AMPAJ	26.5	RCGM	1.147	NACH	59.028
GIVC	6	JLGB	21.42			HDVSAP	56.944
Time 6–15 Net. Size 20							
DEGREE	Score	EIGENVECTOR	Score	BETWEENNESS	Score	CLOSENESS	Score
AMPAJ	10	AMPAJ	58.77	AMPAJ	43.59	AMPAJ	75.439
DF-TM	8	W-TM	47.32	DF-TM	31.95	DF-TM	71.053
W-TM	8	LAMREG	43.85	W-TM	15.67	W-TM	71.053
LAMREG	7	DF-TM	40.53	HDVSAP	14.33	LAMREG	67.544
GIVC	6	GIVC	39.41	LAMREG	10.72	HDVSAP	58.772
HDVSAP	5	CCVC	35.07	MAPSP	3.548	GIVC	58.333
SPRVP	5	SPRVP	35.07	JLGB	3.099	JLGB	57.895
ESPG	5	DAPR	35.07	GIVC	2.729	ESPG	55.702
CCVC	5	ESPG	35.07			CCVC	55.702
DAPR	5	JLGB	29.51			SPRVP	55.702

Centrality Measures times 16–24 (continued)

TOP 10 X TIME							
Time 16–17 Net. Size 15							
DEGREE	**Score**	**EIGENVECTOR**	**Score**	**BETWEENNESS**	**Score**	**CLOSENESS**	**Score**
DF-TM	8	W-TM	63.83	DF-TM	40	DF-TM	78.571
W-TM	8	LAMREG	58.35	HDVSAP	21.5	W-TM	78.571
LAMREG	7	DF-TM	51.98	W-TM	17.66	LAMREG	73.81
HDVSAP	5	RCGM	44.32	AMPAJ	16.23	HDVSAP	67.857
RCGM	5	DCCS	38.84	LAMREG	12.13	AMPAJ	66.667
AMPAJ	5	HAJPE	38.84	RCGM	3.48	RCGM	63.095
HAJPE	4	AMPAJ	37.79	MAPSP	3.297	HAJPE	57.143
DCCS	4	HDVSAP	34.46			DCCS	57.143
JCG	3	JLGB	32.94			JLGB	57.143
FCMP	3	JCG	15.81			MAPSP	53.571
Time 18–21 Net. Size 13							
DEGREE	**Score**	**EIGENVECTOR**	**Score**	**BETWEENNESS**	**Score**	**CLOSENESS**	**Score**
DF-TM	7	W-TM	64.55	DF-TM	44.7	DF-TM	79.167
W-TM	7	LAMREG	58.41	HDVSAP	33.84	W-TM	79.167
LAMREG	6	RCGM	50.23	W-TM	18.69	LAMREG	72.222
HDVSAP	5	DF-TM	49.81	LAMREG	10.35	HDVSAP	70.833
RCGM	5	HAJPE	44.09	RCGM	6.061	RCGM	66.667
HAJPE	4	DCCS	44.09			HAJPE	59.722
DCCS	4	HDVSAP	36.4			JLGB	59.722
FCMP	3	JLGB	35.06			DCCS	59.722
ARAP	3	JCG	17.01			FCMP	55.556
JCG	3	FCMP	17.01			ARAP	55.556
Time 22–23 Net. Size 9							
DEGREE	**Score**	**EIGENVECTOR**	**Score**	**BETWEENNESS**	**Score**	**CLOSENESS**	**Score**
W-TM	6	W-TM	66.66	HDVSAP	46.43	W-TM	87.5
LAMREG	5	RCGM	61.32	W-TM	32.14	RCGM	81.25
RCGM	5	LAMREG	60.68	RCGM	16.07	LAMREG	77.083
HDVSAP	4	DCCS	55.34	LAMREG	5.357	HDVSAP	75
HAJPE	4	HAJPE	55.34			HAJPE	70.833
DCCS	4	HDVSAP	32.36			DCCS	70.833
JLGB	2	JLGB	28.88			JLGB	58.333
MAPSP	1	MAPSP	7.338			MAPSP	47.917
FGRC	1	FGRC	7.338			FGRC	47.917
Time 24 Net. Size 4							
DEGREE	**Score**	**EIGENVECTOR**	**Score**	**BETWEENNESS**	**Score**	**CLOSENESS**	**Score**
HDVSAP	2	-	-	HDVSAP	33.33	HDVSAP	66.667
MAPSP	1	-	-			MAPSP	50
FGRC	1	-	-			FGRC	50
JLGB	0	-	-			JLGB	0

D. TOPOGRAPHICAL MEASURES AND CENTRALIZATION

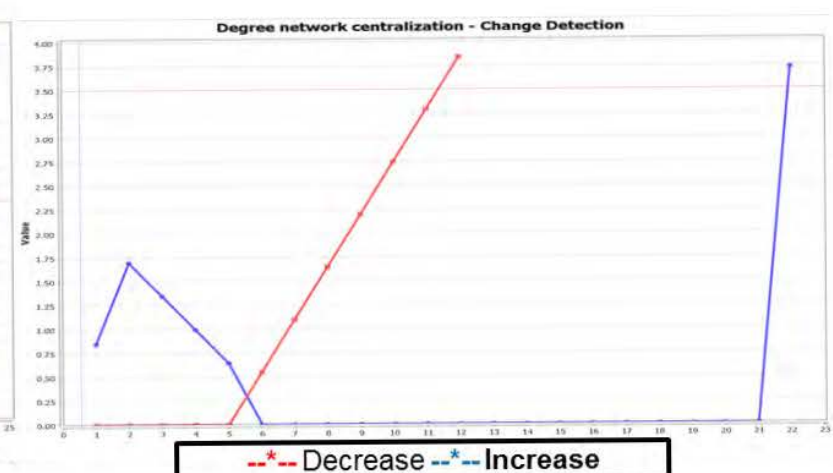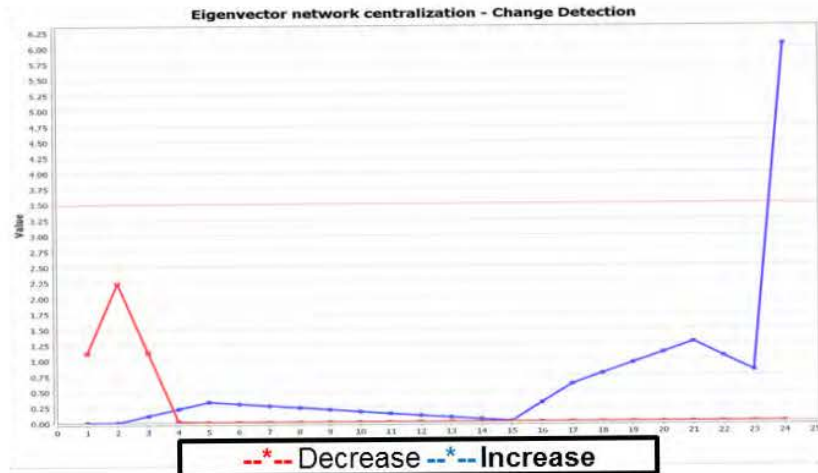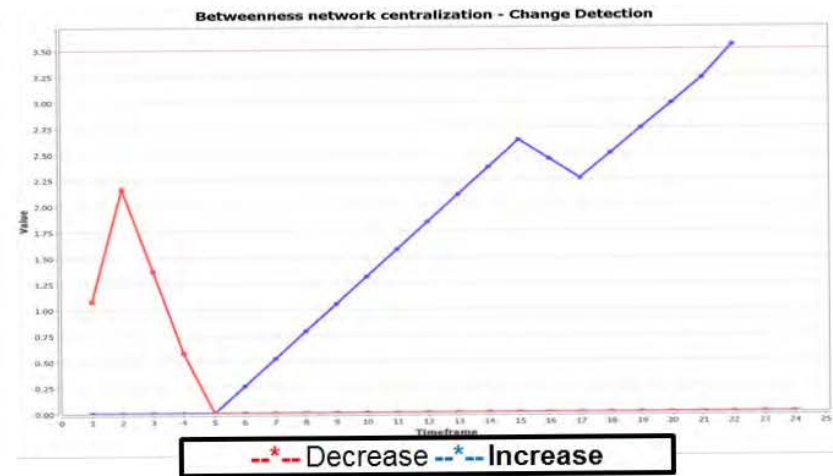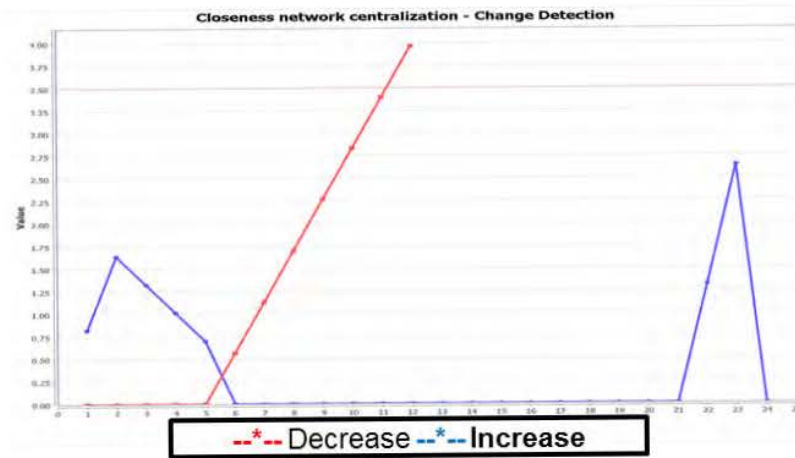| Time n=month ==>24					
Time	**1-2**	**Time**	**3-5**	**Time**	**6-15**
size	11	size	25	size	20
Avg. degree	6.1	Avg. degree	5.8	Avg. degree	4.8
Density	0.61	Density	0.24	Density	0.25
Degree centralization	34.44 %	Degree centralization	32.43 %	Degree centralization	30.41 %
Degree standard deviation	2.52	Degree standard deviation	3.16	Degree standard deviation	2.14
Eigenvector centralization	20.74 %	Eigenvector centralization	42.17 %	Eigenvector centralization	41.55 %
Eigenvector standard deviation (norm.)	16.84	Eigenvector standard deviation (norm.)	17.01	Eigenvector standard deviation (norm.)	14.02
Betweenness centralization	15.78 %	Betweenness centralization	34.46 %	Betweenness centralization	39.17 %
Betweenness standard deviation (norm.)	8.55	Betweenness standard deviation (norm.)	10.28	Betweenness standard deviation (norm.)	11.63
Closeness centralization	37.65 %	Closeness centralization	45.17 %	Closeness centralization	41.66 %
Closeness standard deviation (norm.)	14.79	Closeness standard deviation (norm.)	9.65	Closeness standard deviation (norm.)	8.96
Clustering Coefficient (wtd)	0.85	Clustering Coefficient (wtd)	0.62	Clustering Coefficient (wtd)	0.58
Time	**16-17**	**Time**	**18-21**	**Time**	**22-23**
size	15	size	13	size	9
Avg. degree	4.2	Avg. degree	4	Avg. degree	3.5
Density	0.3	Density	0.33	Density	0.44
Degree centralization	30.77 %	Degree centralization	29.55 %	Degree centralization	39.29 %
Degree standard deviation	2.02	Degree standard deviation	1.88	Degree standard deviation	1.71
Eigenvector centralization	46.45 %	Eigenvector centralization	45.77 %	Eigenvector centralization	43.45 %
Eigenvector standard deviation (norm.)	17.47	Eigenvector standard deviation (norm.)	18.67	Eigenvector standard deviation (norm.)	21.99
Betweenness centralization	34.69 %	Betweenness centralization	38.95 %	Betweenness centralization	39.73 %
Betweenness standard deviation (norm.)	11.36	Betweenness standard deviation (norm.)	14.26	Betweenness standard deviation (norm.)	16.21
Closeness centralization	40.62 %	Closeness centralization	39.45 %	Closeness centralization	45.76 %
Closeness standard deviation (norm.)	10.43	Closeness standard deviation (norm.)	10.92	Closeness standard deviation (norm.)	13.34
Clustering Coefficient (wtd)	0.53	Clustering Coefficient (wtd)	0.59	Clustering Coefficient (wtd)	0.67

Topographical Measures and Centralization (continued)

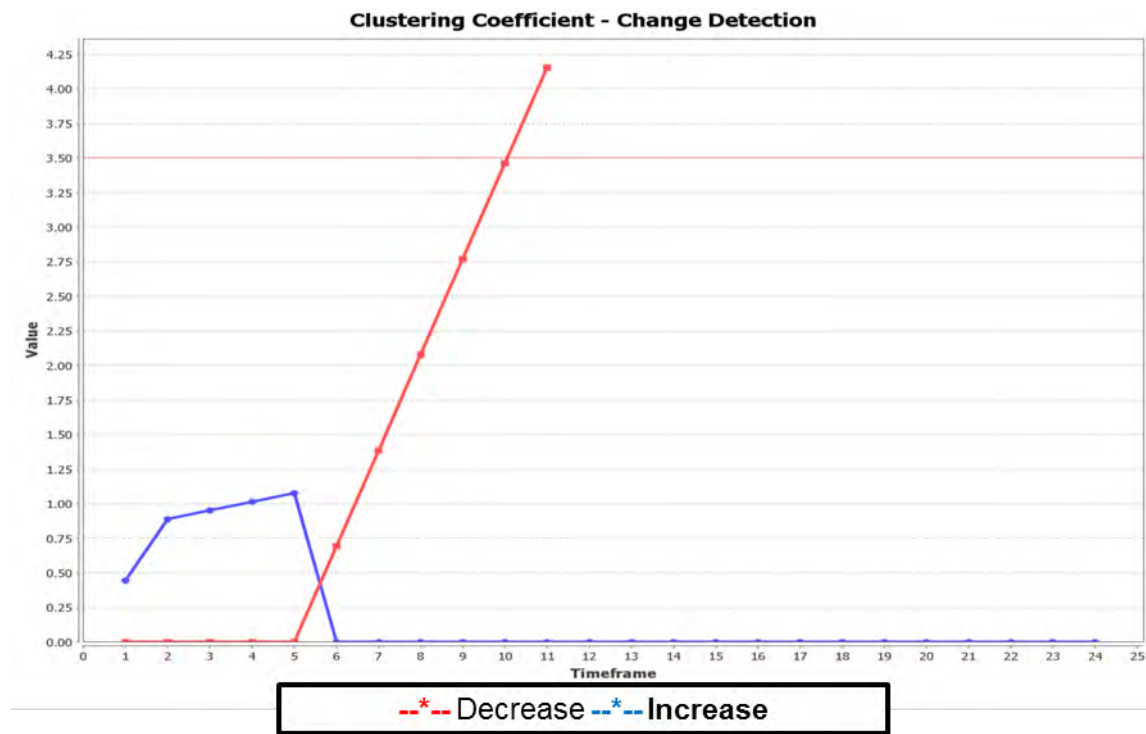| Time	24
size	4
Avg. degree	1
Density	0.33
Degree centralization	66.67 %
Degree standard deviation	0.71
Eigenvector centralization	----
Eigenvector standard deviation (norm.)	----
Betweenness centralization	33.33 %
Betweenness standard deviation (norm.)	14.43
Closeness centralization	83.33 %
Closeness standard deviation (norm.)	25.00
Clustering Coefficient (wtd)	0.00

E. NETWORK TRANSFORMATION OVER TIME
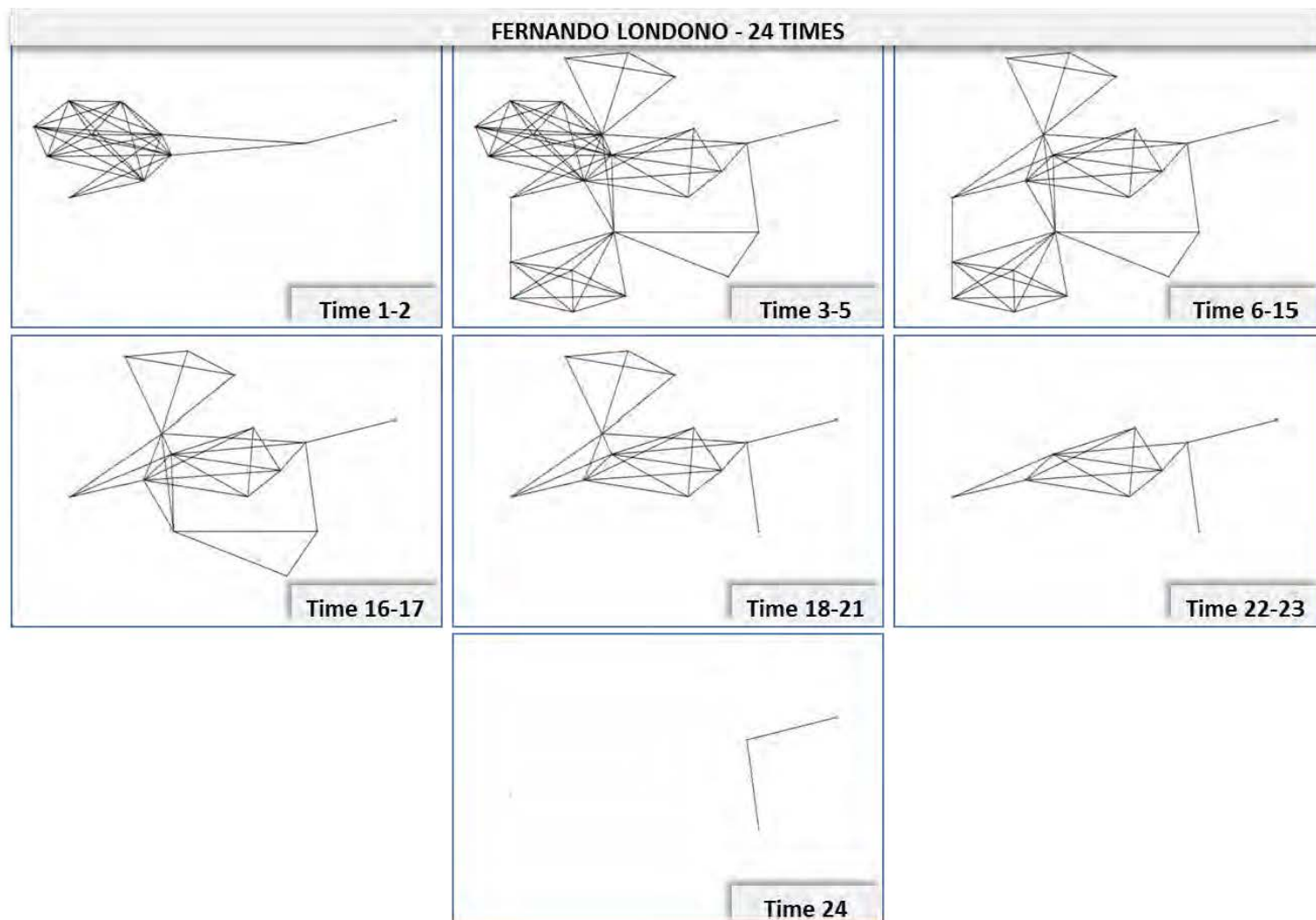
FERNANDO LONDONO - 24 TIMES

F. SOCIAL NETWORK CHANGE DETECTION

Closeness network centralization - Change Detection

--*-- Decrease --*-- Increase

Betweenness network centralization - Change Detection

--*-- Decrease --*-- Increase

Eigenvector network centralization - Change Detection

--*-- Decrease --*-- Increase

Degree network centralization - Change Detection

--*-- Decrease --*-- Increase

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Social Network Change Detection (continued)

Clustering Coefficient - Change Detection

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